A study of curriculum development and evaluation in integrated science.

Kirby, D M

APPENDIX B

Student Materials

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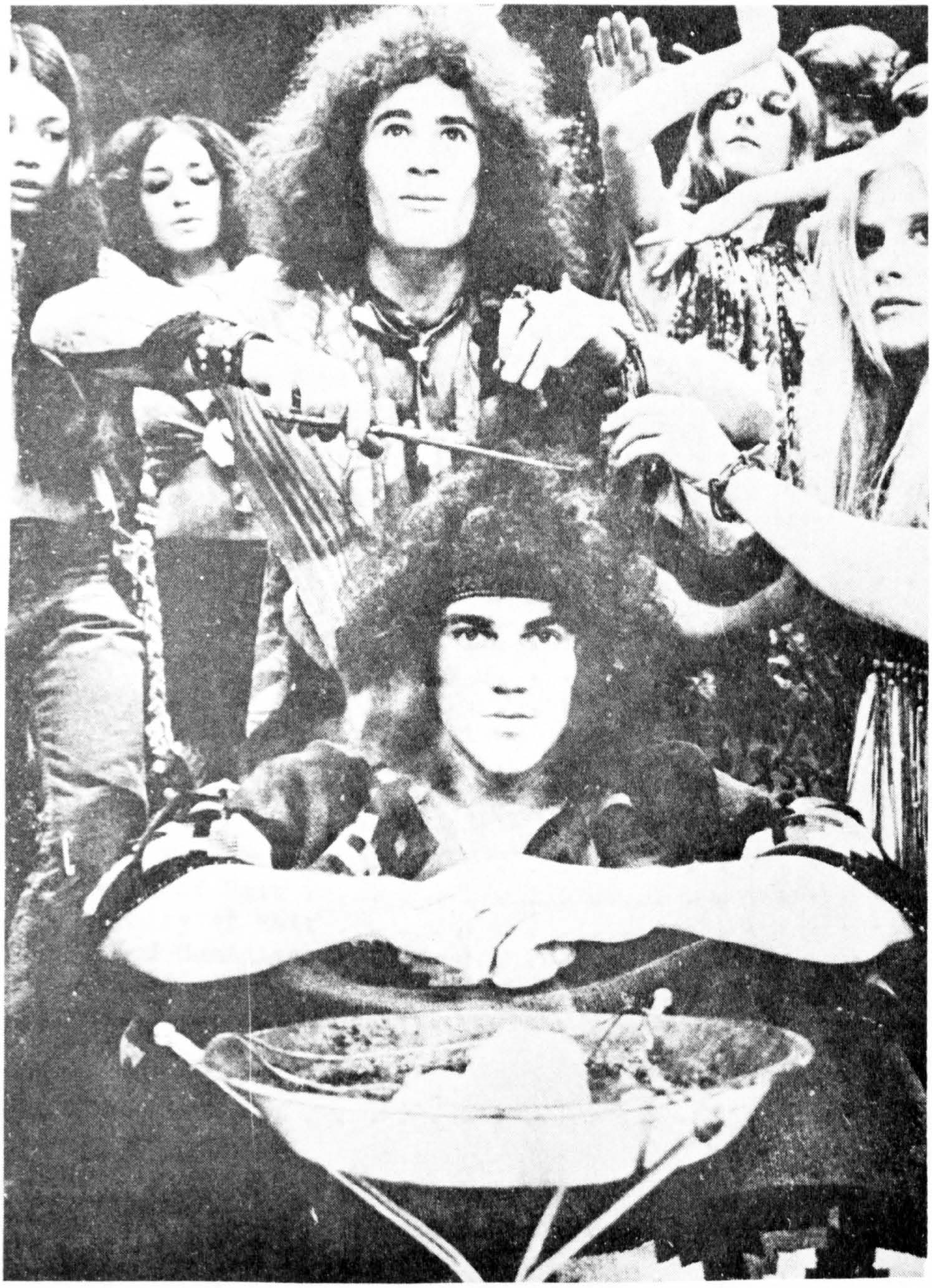
INTEGRATED SCIENCE FOR NEWFOUNDLAND

MODULE I – HAIR

SCHOOL: ______________________________

NAME: ______________________________

HAIR



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I. INTRODUCTION

"Let it fly in the breeze,
And get caught in the trees.
Give a home for the fleas in my hair.
A home for the fleas,
A hive for the bees,
A nest for the birds.
There ain't no words
For the beauty, the splender, the wonder
of my hair."

Your teacher has just played you a tape recording of the title song from the rock musical "Hair". This may be an unusual introduction to a science module but it does emphasize some of the importance we attach to hair in our society. If you listen carefully to the lyrics of the song, it appears the most important function would be personal adornment. However hair has many other uses, and although we will not look at the light-hearted ones suggested in the brief quotation from the song printed above, we will look at several important functions of hair. This module also considers the other aspects of hair, what it is, how it grows, and what properties it has. You will also look at the importance that is attached to it in society, and investigate some of the claims that are made in the many advertisements about hair.

Having spend a few minutes listening to the tape, some questions about hair may have occurred to you. Note down any that you can think of, and at the end of the module you can see whether you have answered them.

The reprint "Joe's Hair", taken from the Reader's Digest is useful background reading on the topic. You may want to read it through now, and also as you reach various points in the topic.

READER'S DIGEST **REPRINT**

I AM JOE'S HAIR

By J. D. Ratcliff

A lot of nonsense has been written about me. Here's the inside story of what really gives me my special character

For all practical purposes I am useless—one of the few parts of Joe's body with nothing to do.* Yet he is more concerned about me than about most of his life-and-death organs. He and his wife Jane lavish time, attention and money on me and my associates. I am hair No. 56,789 in Joe's head and will speak for the millions of others scattered over his body.

We hairs come in various sizes and shapes: stiff and short in the eyebrows; long and soft on the head; downy and virtually invisible on most other body areas. There are 100,000 of us on Joe's scalp, 30,000 in his beard. We are among the fastest-growing tissues in his body. Each year Joe will produce about 5½ inches of beard, and about 5 inches of scalp hair.

What are we hairs and where do we come from? Buried about an eighth of an inch down in the corium—that layer of skin beneath the epidermis that contains the blood and nerves—I have a tiny follicle. The follicle is simply a minute hair factory, an amazing and complex affair that operates 24 hours a day for up to seven years and then shuts down for rest and repairs. After a rest period, my follicle will crank up and start producing again. I usually drop out and am replaced by a new hair—Joe loses some 75 of us scalp hairs a day.

At two months our follicles started forming when Joe was in his mother's womb. They began producing a silky down called lanugo. At seven months Joe shed this.

* Joe, 47, is a typical businessman. A number of components of his body have told their stories in previous articles in The Reader's Digest.

When Joe was a child, soft, short "vellus" hair covered most of his body. At puberty, many of the follicles that had been producing vellus hair changed and started producing the coarser "terminal" hair that Joe has today. Another curious point about hair – eventually many scalp follicles may degenerate and start producing vellus hair instead of terminal hair or they may shut down completely. That's ordinary baldness.

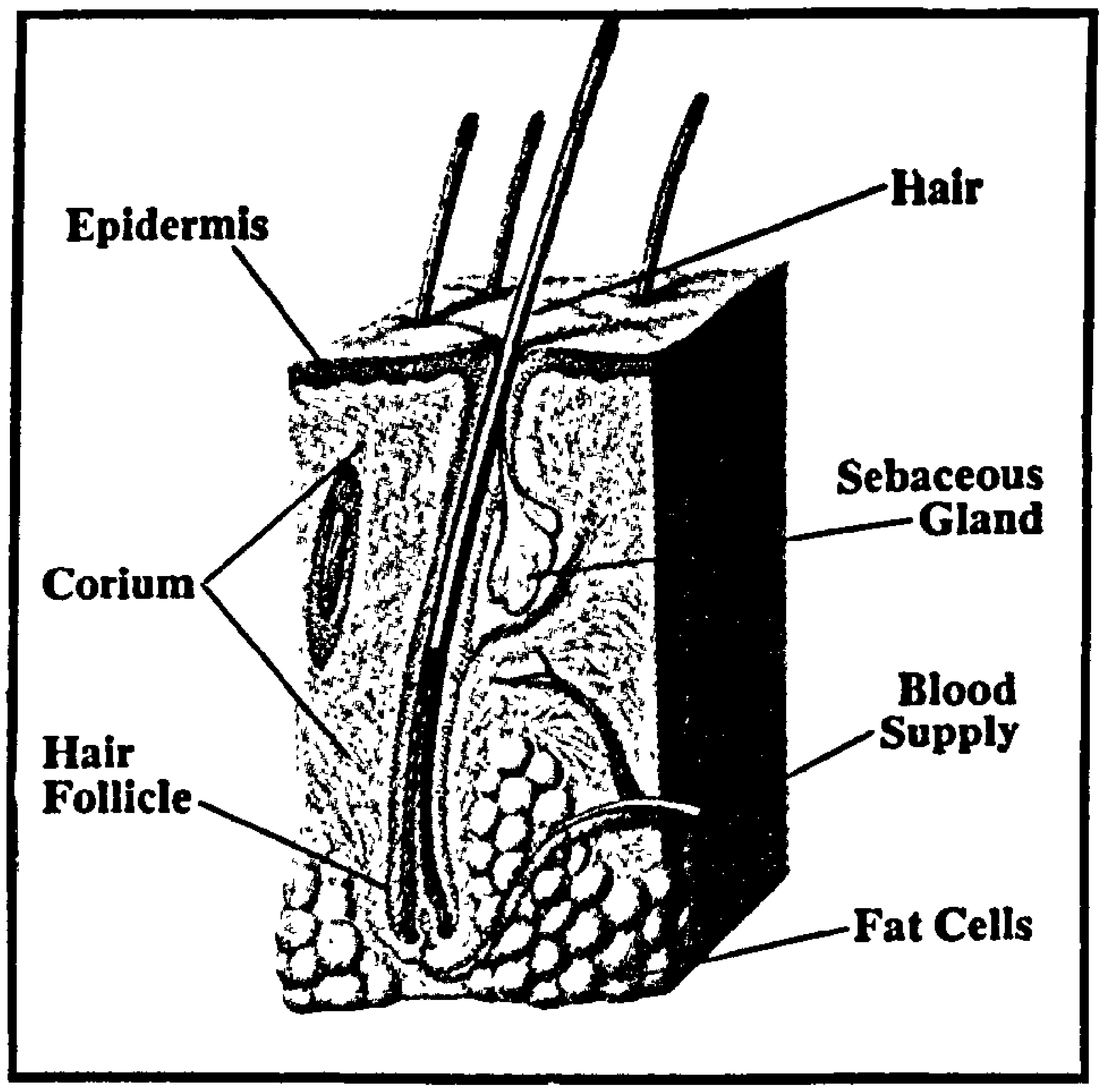
When Joe reaches old age, we hairs will become smaller in diameter as his factory decreases in size. Our quality, as a general rule, will become poor.

When Joe plucks one of his scalp hairs, he may note a small club at the end. He's afraid the hair won't be replaced. It will. This club is simply the terminal end of a hair from a resting follicle, which is about to be shed anyway. The essential for the production of hair follicles is protein. We hairs are made up almost entirely of protein. It's amazing that anything as tiny as a follicle could turn out a product so intricate. My outer layer has overlapping cells that look like shingles on a roof. This layer gives strength and protection. My middle layer contains fatter elongated cells which give bulk. I am quite elastic and under certain conditions can be stretched my length. I am also surprisingly strong and can support about a three-ounce weight.

As my follicle creates and arranges my cells to make this complex structure, it gives me a little squirt of coloring matter, which is parceled out in tiny granules. Hair color depends on the shape, number and distribution of these granules, as well as the type of pigment present – brown-black or yellow-red. Each follicle also has attached sebaceous glands to provide its hair with lubricating and waterproofing fat.

Newly produced hair cells are living affairs. As they are pushed upward through the hair canal, a hardening process called keratinization sets in. The part of my hair above the surface is dead. The keratin we hairs are made of is also found in the horns of a cow, feathers of a duck and hoofs of a goat.

The production rate of individual follicles varies around Joe's body. Some – like those of his eyebrows and eyelids – rest most of the time. My follicle is one of the more active ones. It produces about half an inch of hair a month. The follicles that produce Joe's whiskers are slightly faster. Although Joe's wife, Jane, has about the same number of follicles as Joe, most of her follicles produce a quite different type of hair. Her body and facial hair is mostly a fine, almost invisible down – the same vellus hair that covered Joe as a child. She can thank her stars that this is so. Otherwise she might be bearded and hairy-chested.



Our follicles produce hair that is straight, wavy or curly. In cross-section we might have one of three basic shapes: round, oval or flattened. Round is for straight hair; oval is for wavy hair; flattened is for kinky hair. Of course, there are degrees in between. The flatter we hairs are, the curlier we are; the rounder we are, the straighter.

Joe is now 47 and noticing gray hairs. This is because my pigment glands are slowing production and in time Joe will have white hair.

In a sense, we hairs are record keepers for Joe's body. Minute portions of what he consumes are apt to show up in us, particularly metals. Joe frets about lead pollution in today's air from motor exhaust. If he had a snippet of his grandfather's hair, it might contain several times as much lead as Joe's. The old gentleman could have got it from lead plumbing and lead-glazed earthenware. Should someone decide to slip arsenic into Joe's tea, a chemist could examine his hair and know, to within 48 hours, when Joe was dosed. As a matter of fact, there is talk of using us hairs to help diagnose disease. A look at us with a scanning electron microscope, or by X-ray analysis, can show whether Joe is suffering from certain hereditary diseases.

Our health is totally dependent on Joe's general health. A variety of diseases involving high fever can cause our follicles to shut down temporarily and Joe's hair to fall out. In an unusual case, sustained emotional states might cause an abnormal number of follicles to enter my resting stage and bring on temporary baldness.

A lot of nonsense has been written about us. One common belief is that shaving thickens and coarsens hair. Not so. Another belief is that baldness traces to poor circulation, too much sun, too little sun. It isn't any of these. Suppose Joe got a bald patch. He could have hair grafts containing 8 to 12 hairs each taken from his neck and transplanted to cover the bald spot. And these transplants would thrive on the supposedly infertile soil.

Heredity plays a big role. Had Joe's father been bald, Joe's chances for baldness would have been 50-50. Had both parents been bald, his chances would be much greater. Glands also play a role with Joe's hair. At puberty Joe's male glands began producing large amounts of the hormone testosterone. Terminal hair began sprouting in the pubic area, armpits, and on legs and chest. Downy facial hair darkened and coarsened.

Hormones also affect Jane's hair. During pregnancy she had excess female hormone. She noted that her head hair grew luxuriantly. A few months or so after delivery, she started losing hair by the combful. However, she needn't have worried. In a short time normal hormonal order was restored and her hair problems ended.

Thyroid hormone also plays a part. Too much thyroid hormone and hair grows profusely; too little, it is lusterless and tends to fall out.

Like other organs, we hairs have a wide array of diseases to cause us trouble. We can get minute tumors on our follicles which destroy them. We are hit by fungus diseases (ringworm). Certain drugs cause us to fall out – as does excessive Vitamin A. One strange ailment is alopecia areata – patchy baldness. Cause? I don't really know. Heredity has something to do with it. But it is the darling of "hair experts." At Joe's age, they know, hair is likely to grow back anyway after a few months and their ministrations will get the credit.

Hair care? We hairs tend to trap dust, bacteria and other debris, so shampooing once a week is a good idea. Too much exposure to summer sun can make hair dry, brittle and discolored; wear a scarf or hat to protect us. And rinsing or shampooing after swimming will prevent dryness. Otherwise, about the best advice I can give is this: keep your bodies in good health and I will be in good health.

Reprinted from the April 1973 issue of The Reader's Digest.

II. STRUCTURE OF HAIR

Most of us, spend a considerable amount of our time with our hair. We may well take it for granted and yet it is a very complex substance with many fascinating properties. So let us start by considering the structure of hair.

Looking at Hair

Pluck a few hairs from your head. Make sure that the hair is removed complete, that is, with the 'root' still attached. Examine one carefully with a hand lens. In the space below make a simple sketch of what you see.

If possible, remove an eyelash or eyebrow, and make a sketch below.

With a hand lens you will not be able to see a great deal, but you should be able to decide whether a hair is the same thickness all the way along its length.

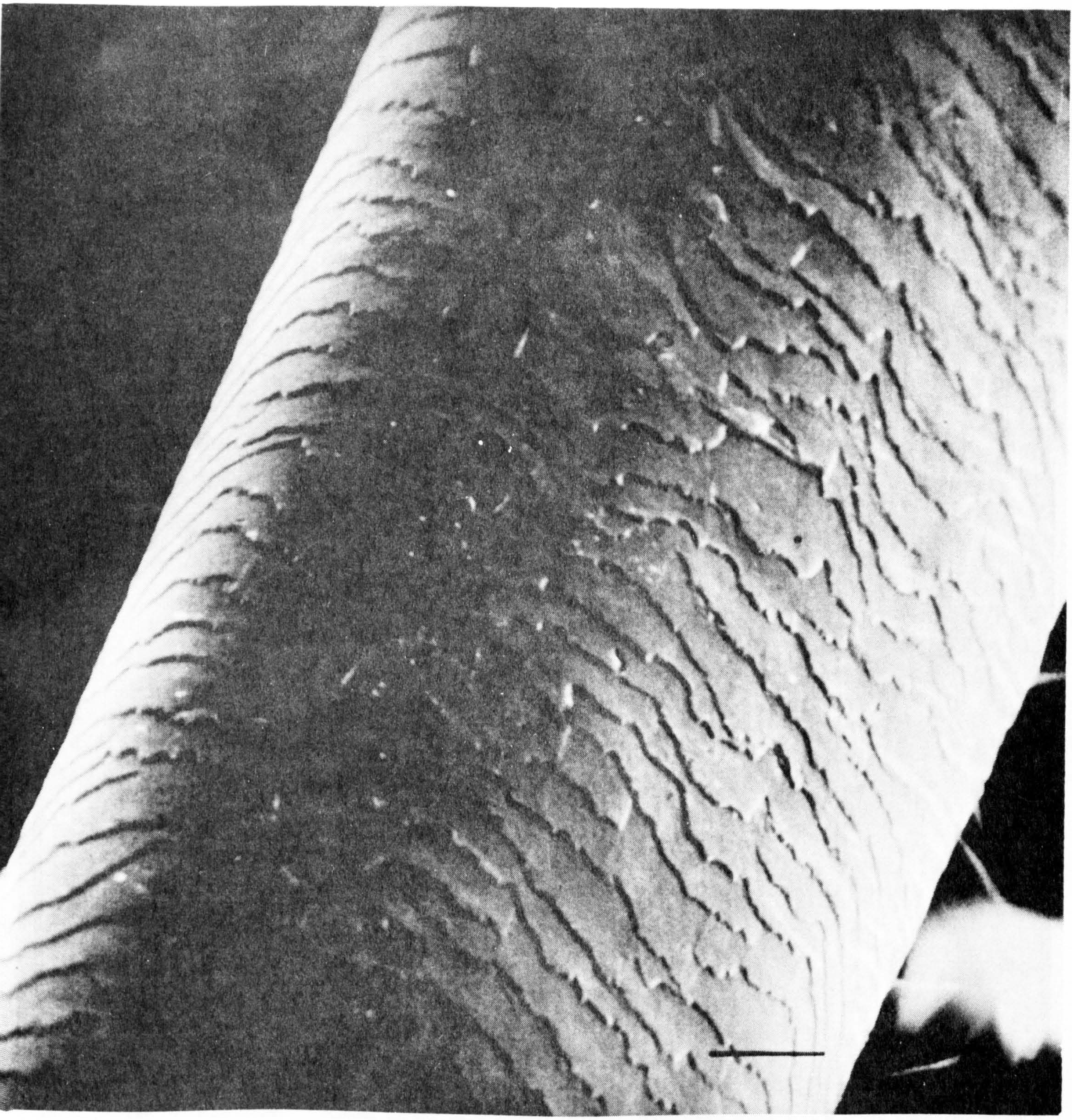
We obviously need to use a more powerful instrument to see more detail. Your teacher will show you how to prepare a slide correctly to enable you to look at a hair under a microscope. Describe below briefly the procedure used. Include a drawing of your hair, and state the magnification used.

Why is it important to include the magnification?

Modern microscopes are very sophisticated compared to the simple instrument first invented by Robert Hooke in 1665. However it is important to realise that there are limits to what we can see with a microscope. The important characteristic of a microscope is what we call the RESOLVING POWER. The resolving power is the ability of the microscope to distinguish between objects which are very close together. Thus the human eye has a resolving power of about 0.1 millimetres, this means the human eye cannot distinguish clearly between two lines which are 0.1 millimetres apart. The best optical microscopes have a resolving power about 500 times more powerful than the human eye. They are limited by the nature of light, and no matter what improvements are made to the lenses, no better resolution can be obtained.

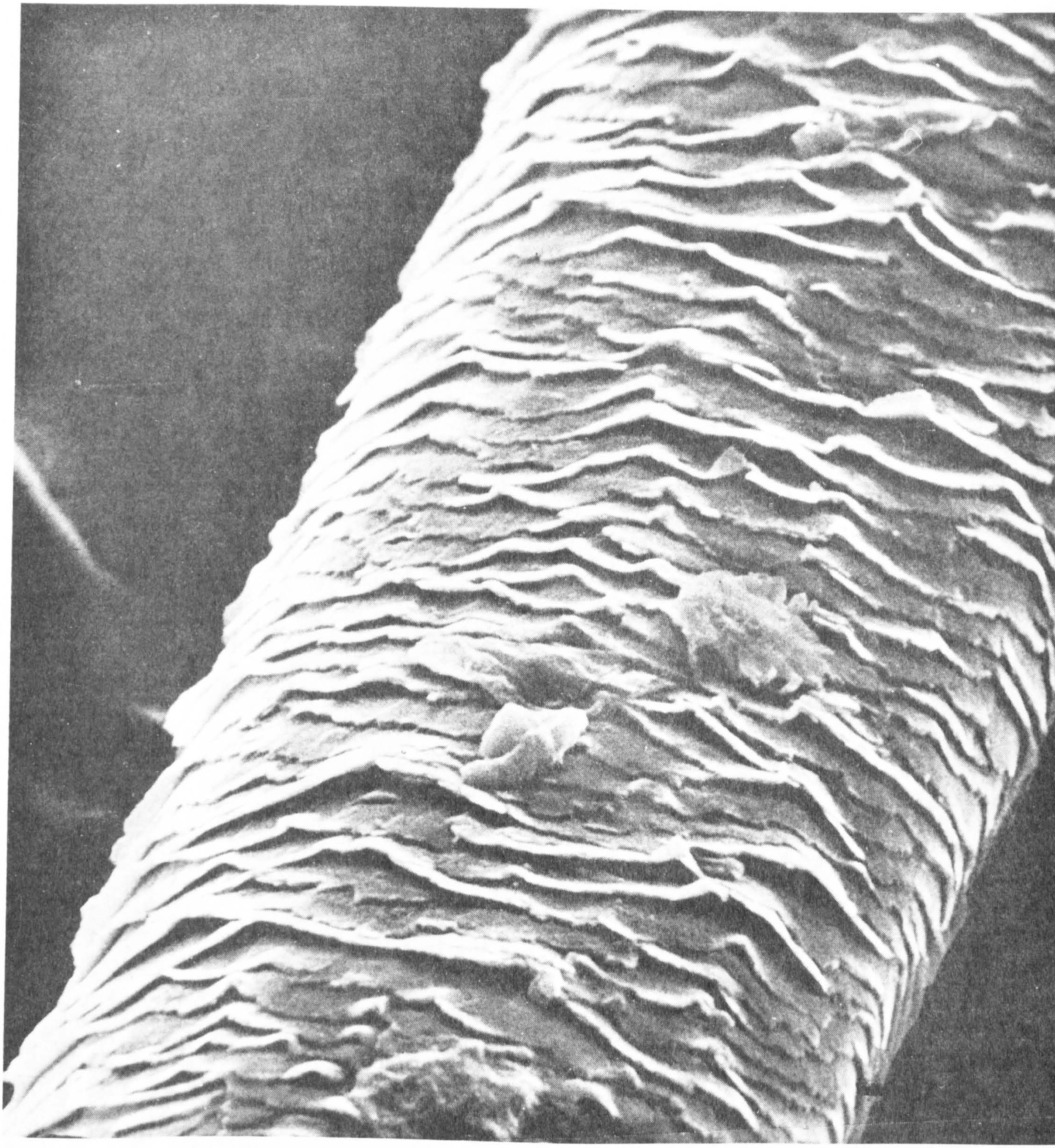
What is the minimum distance apart of two objects that can be resolved by the light microscope?

Because of the limitation in the instruments available to them, scientists were unable to make progress in the study of many branches of Biology. However, a new instrument, the ELECTRON MICROSCOPE, was invented. This instrument used a beam of electrons rather than light to illuminate the object. The resolving power of the electron microscope was 10,000 times more powerful than the human eye. The invention of the electron microscope was a major breakthrough in science, and enabled biologists to study the fine details of cell structure. The pictures on the following pages are taken with an electron microscope, and enable us to see more detailed structure of hair. The pictures are provided by courtesy of the Gillette Research Institute.



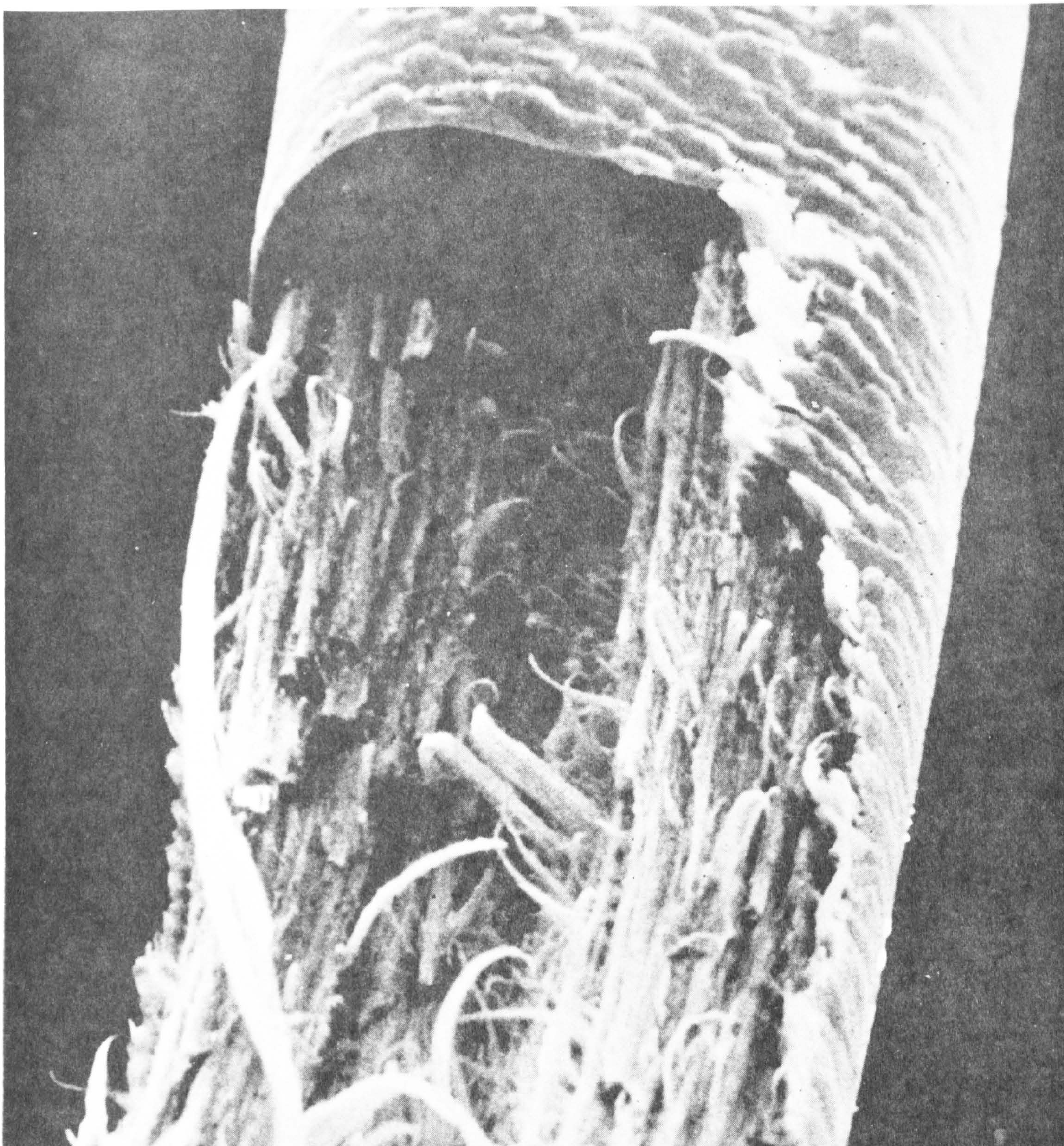
This photograph is of a very clean, shampooed hair in good condition.

(a)



This photograph is of a damaged hair. It was bleached and stretched and as a result the cuticles have been displaced.

(b)



This photograph shows a hair which has the outer part removed to show the internal structure.

Assignment:

Although we have referred to resolving power in terms of millimetres, generally when measuring small distances other units are used. You will often find in texts measurements given in ANGSTROM UNITS, or in MICRONS. (MICROMETRES)

1 ANGSTROM UNIT (A) = 10^{-10} metres = $\frac{1}{10,000,000,000}$ metre = 0.0000000001 metres

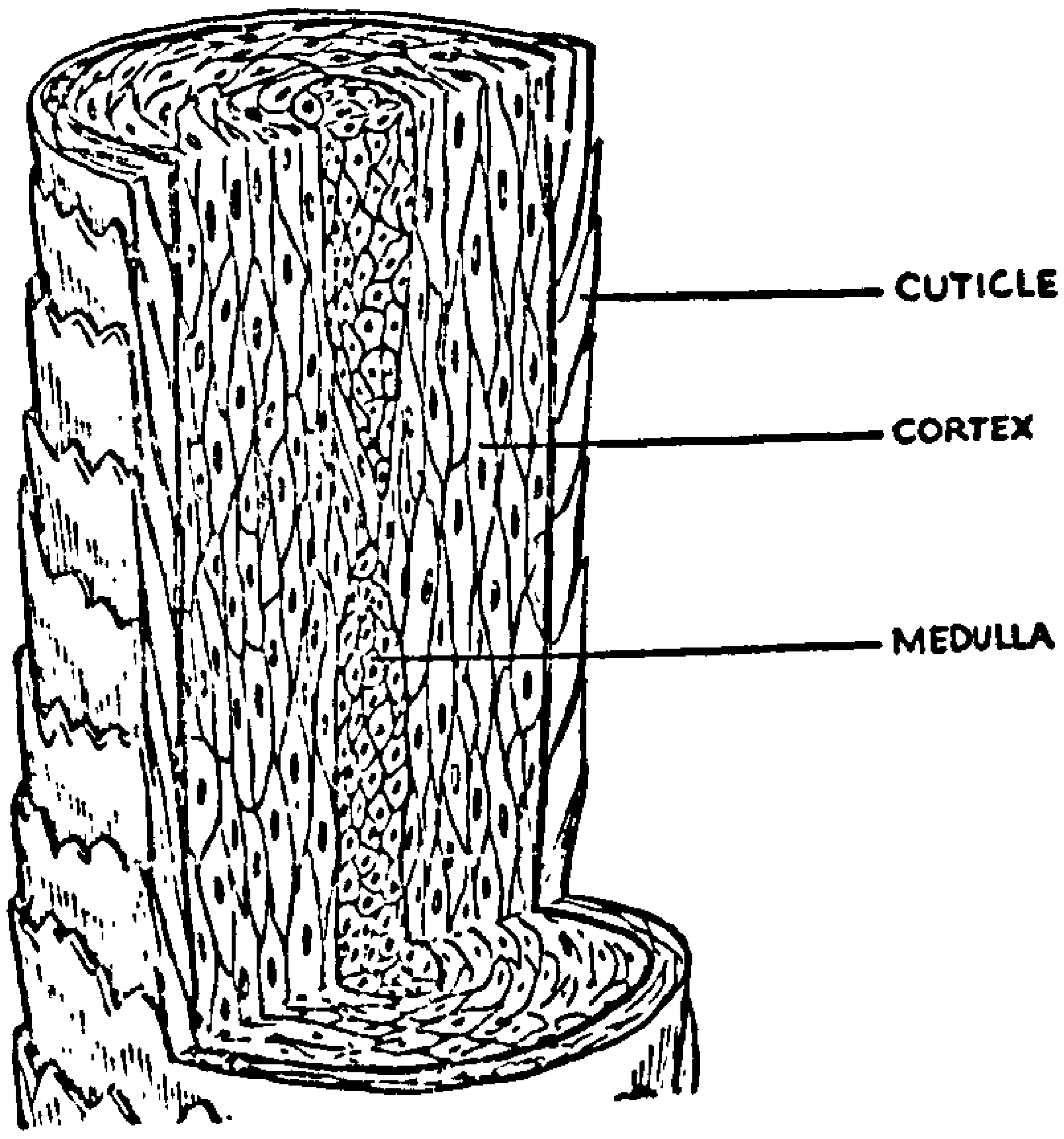
1 MICRON (M) = 10^{-6} metres = $\frac{1}{1,000,000}$ metres = 0.000001 metres

1 MICROMETRE = 1 micron = 10^{-6} metres

Use the information given above to calculate the resolving power of the eye, the light microscope and the electron microscope, in ANGSTROM UNITS and MICRONS.

A detailed examination of the structure of hair with an electron microscope reveals that a hair consists of three layers, the CUTICLE, the CORTEX and the MEDULLA.

The cortex is the largest part of the hair and gives it its strength, the cuticle is a protective layer, while the function of the medulla is not known.



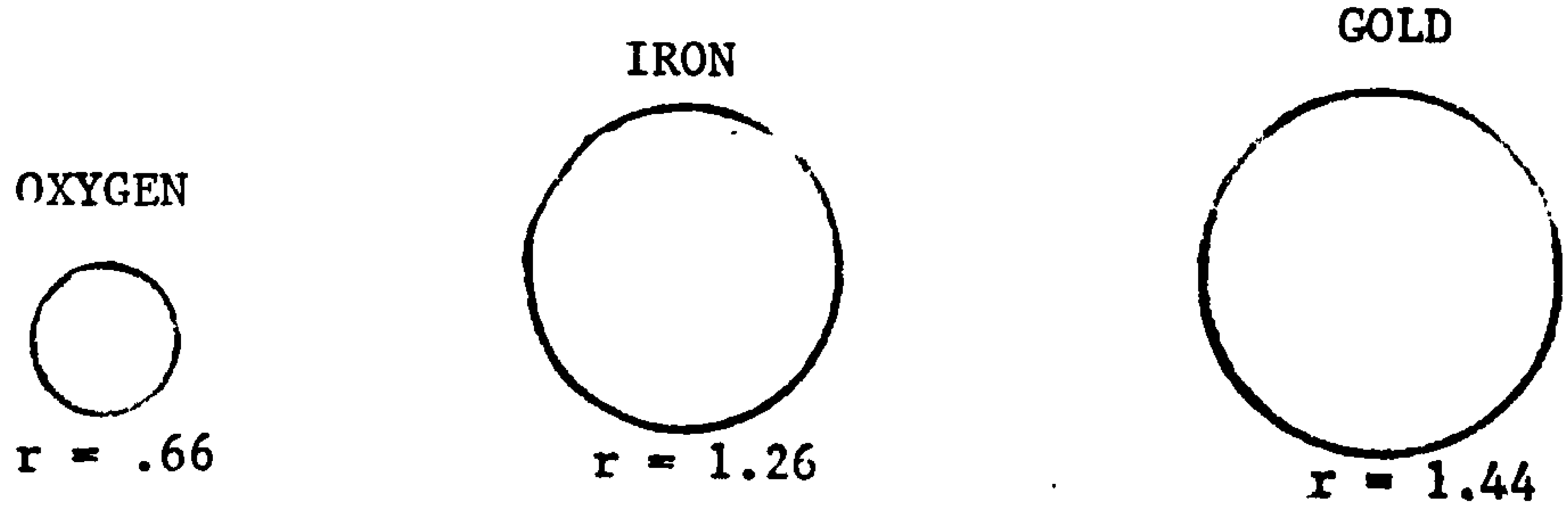
The Composition of Hair - Protein

In the preceeding activities you looked at hair with the naked eye, the optical microscope and looked at some photographs taken with the electron microscope. The electron microscope represents the limit to which we can see the detailed structure of matter. However, scientists have been able to discover much more about the structure of matter. You might well ask how can you investigate something you cannot observe directly. In fact we do this quite often, for example boats in a fog often sound a whistle or a gun, if they hear an echo then they infer there is a cliff or an iceberg nearbye. Scientists sometimes operate in a similar manner, they often have to rely on INDIRECT OBSERVATIONS in order to deduce the properties or structure of an object.

All matter is composed of small particles called atoms, they are the basic building blocks of everything in our universe. We cannot see atoms because they are so tiny. Atoms have sizes in the range of 1-2 Angstrom units, too tiny to be seen even with an electron microscope.

However, as a result of many investigations into the structure of matter, scientists are now convinced of the existence of atoms.

Although there are an almost countless number of atoms in our universe, there are only about a hundred different kinds of atoms known. In the natural world there are 92 different kinds of atoms, and scientists have made about another dozen different kinds in laboratories. Thus all of the different materials in our world, including us, are composed of these comparitively few different types of atoms. If we were able to examine the detailed structure of an iron bar, we would see that it is composed of atoms all of the same type - iron atoms. Similarly gold is composed of gold atoms, and oxygen is composed of oxygen atoms. These different types of atoms differ from each other in terms of size. Thus iron atoms are larger than oxygen atoms.

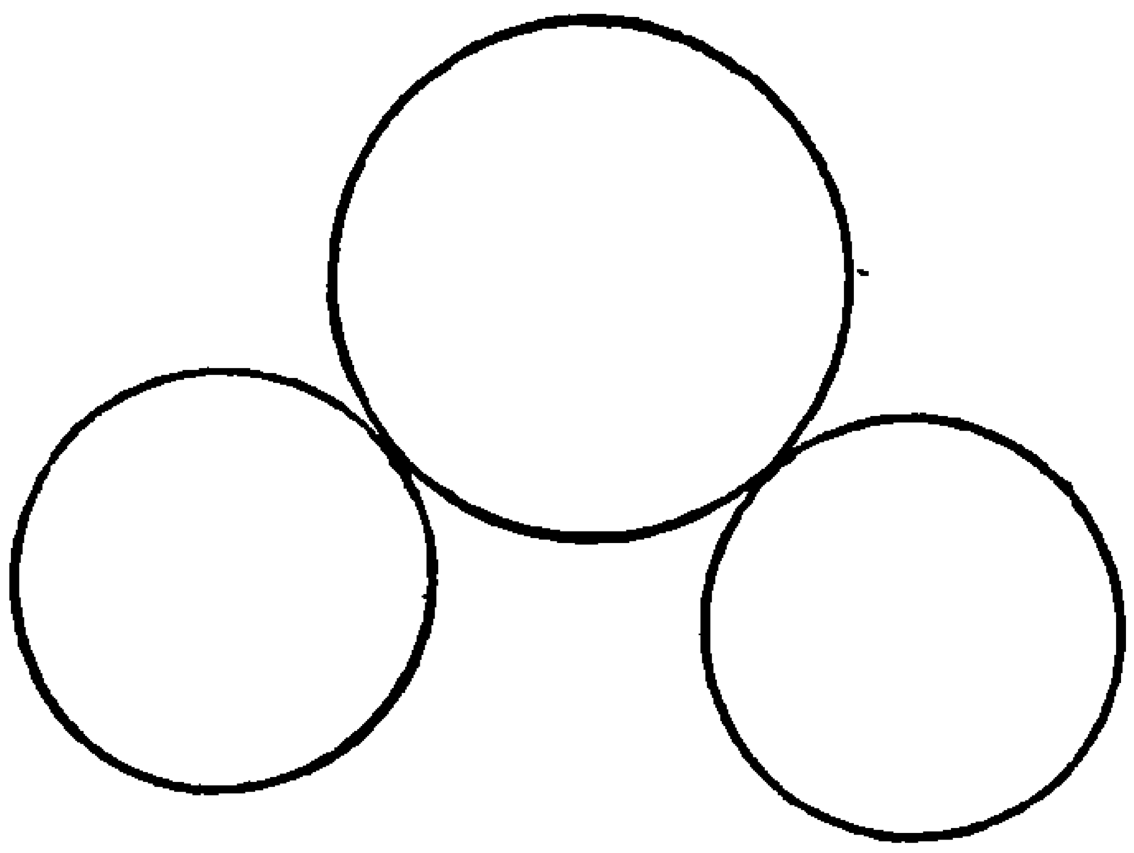


ATOMIC RADII IN ANGSTROMS

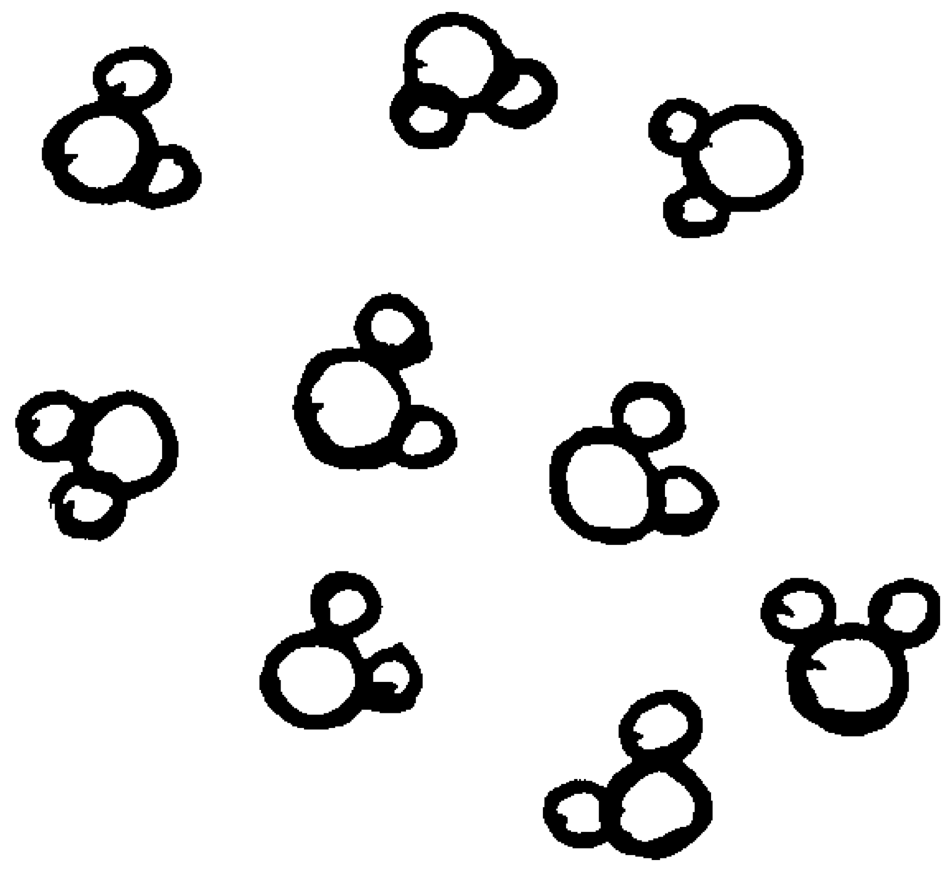
These materials which are composed of a single type of atom are called ELEMENTS. Thus iron, gold, and oxygen are all elements. ELEMENTS are the fundamental materials which compose all matter. Consult a chemistry text for a list of elements. Find out the symbols for the following elements.

TIN	HYDROGEN	LEAD
GOLD	OXYGEN	URANIUM
NITROGEN	IRON	CHLORINE
NEON		

Although there are 92 natural elements there are obviously more than 92 different materials on the Earth. In fact there are several billion different materials. Most of these are COMPOUNDS, formed from two or more elements combined together. Compounds are composed of groups of atoms joined together to form what we call MOLECULES. Thus water is composed of hydrogen and oxygen atoms joined together, such that the smallest unit of water, the water molecule consists of one oxygen atom combined with two hydrogen atoms. Water is a compound.

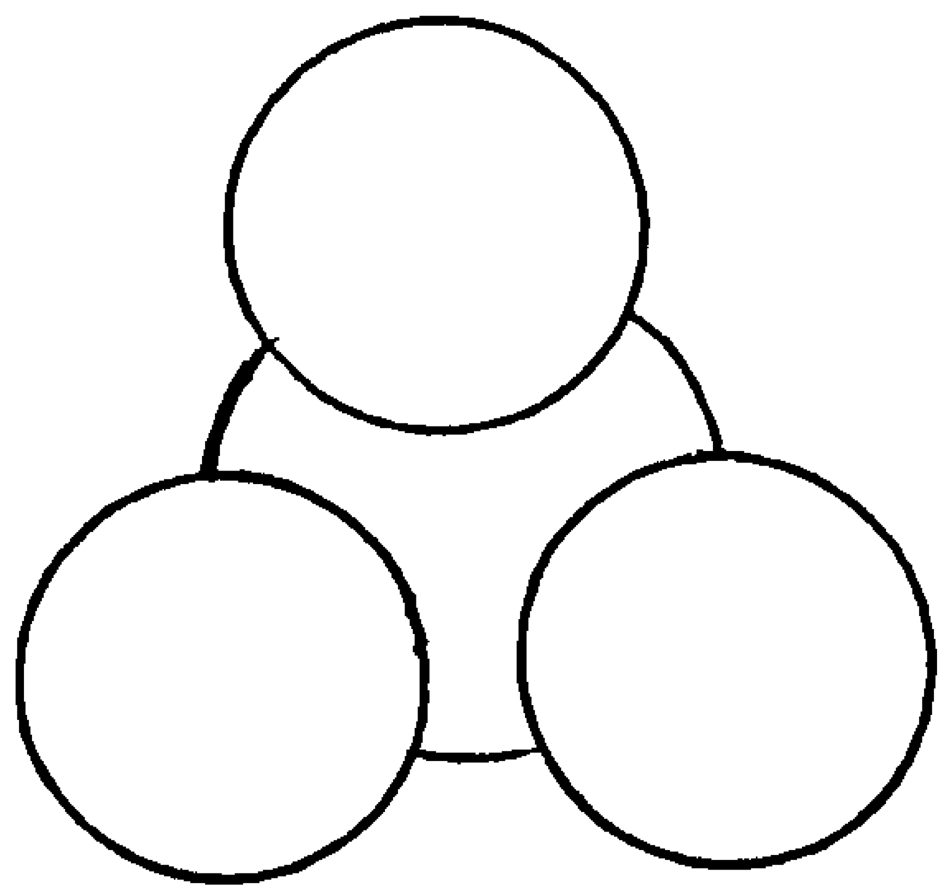


A WATER MOLECULE.



WATER

Similarly ammonia gas, a compound, is composed of ammonia molecules each of which consists of one nitrogen atom and three hydrogen atoms.



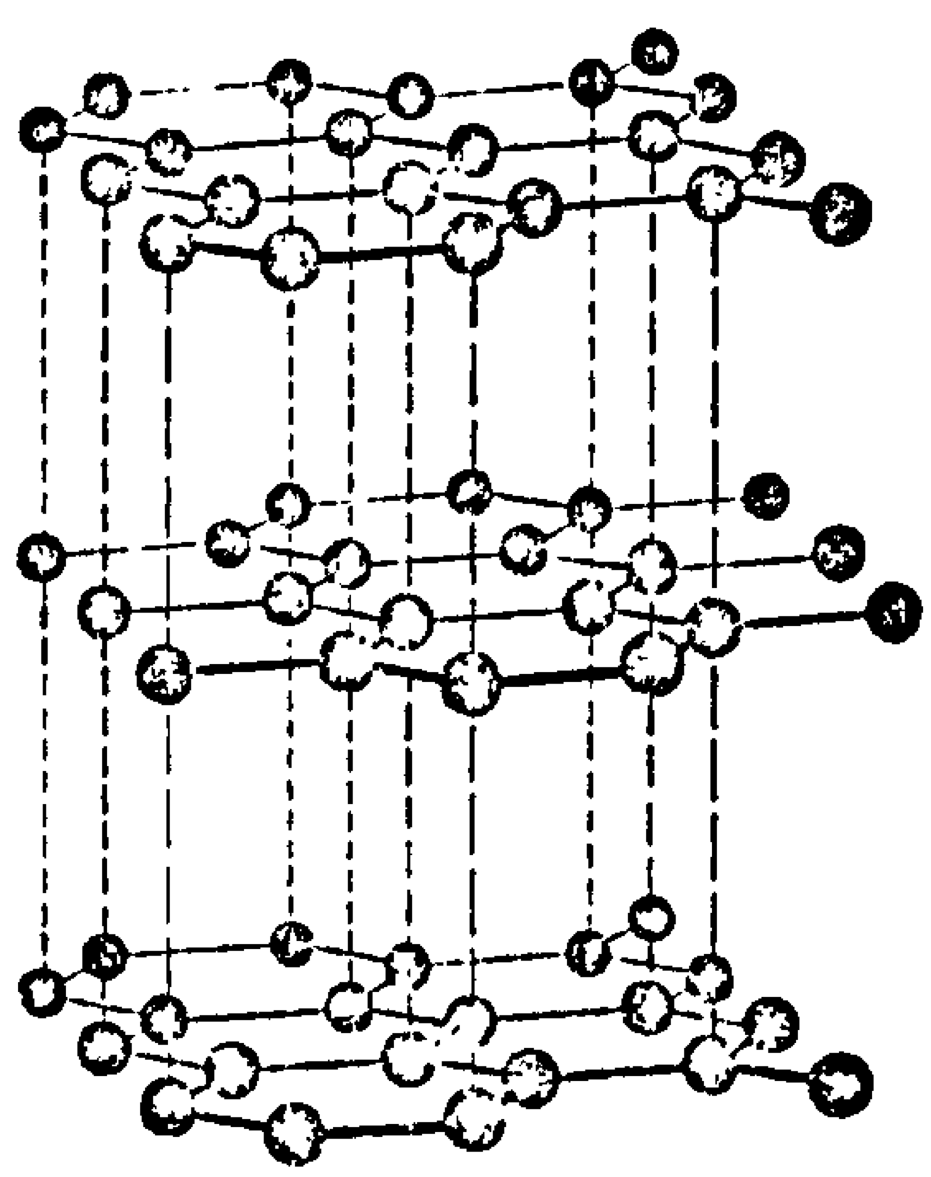
AMMONIA
MOLECULE

We also find atoms of the same type joining together, thus oxygen gas is composed of molecules each of which has two oxygen atoms combined together. Is oxygen an element or a compound?

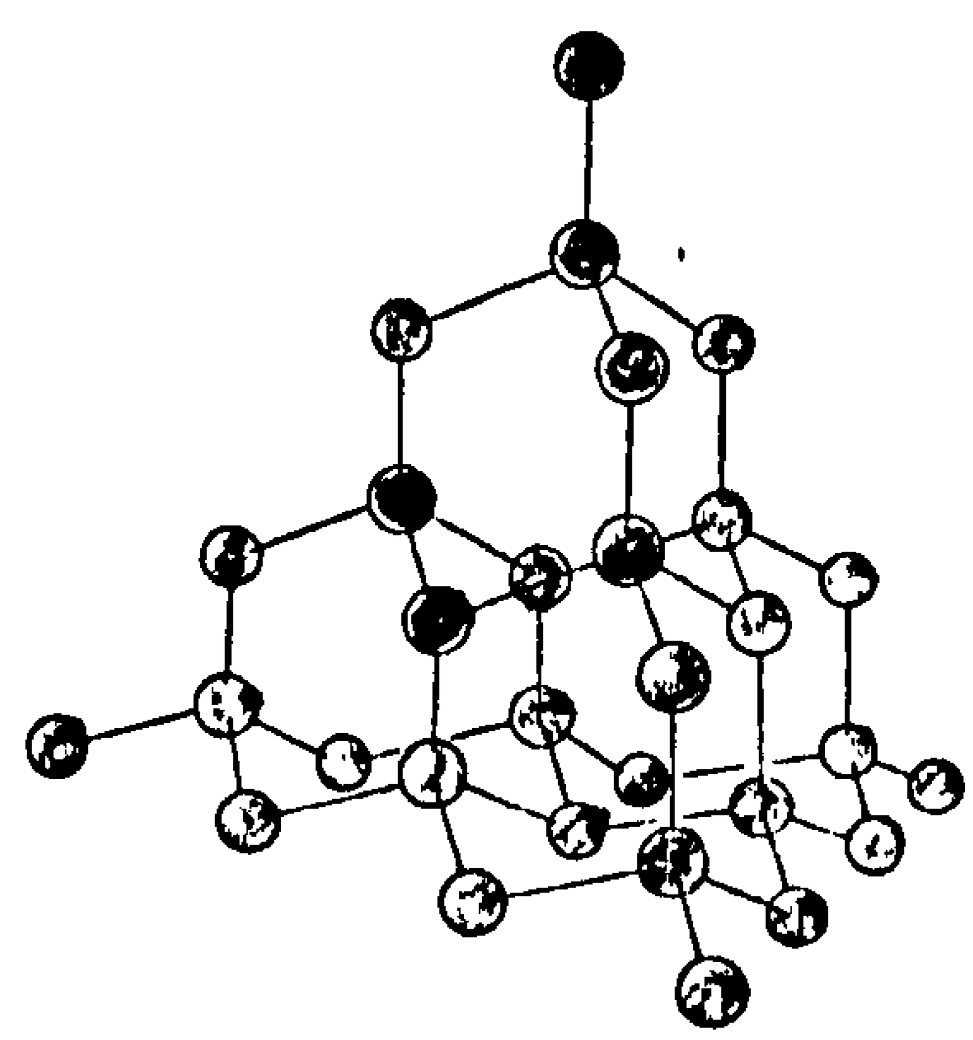
There also exists a gas which consists of molecules made up of three oxygen atoms joined together, this is ozone and it is in fact poisonous, quite a difference from oxygen gas!

The manner in which atoms join together need not concern us now, but we refer to the atoms as being held together by CHEMICAL BONDS. There are different types of chemical bonds, and the bond type will also affect the properties of the materials.

We have considered only some very simple molecules, however many molecules are complicated and consist of large numbers of atoms joined together. The arrangement of the atoms within a molecule can make a considerable difference to the properties of the substance. Thus two forms of the element carbon with which you are familiar, both consist of carbon atoms. One is graphite, which is used for pencil leads and the other is diamond. Although both of these consist of carbon atoms they differ in the arrangement of these atoms, and the result is that they have very different properties.



Crystal structure of graphite



The crystal structure of diamond

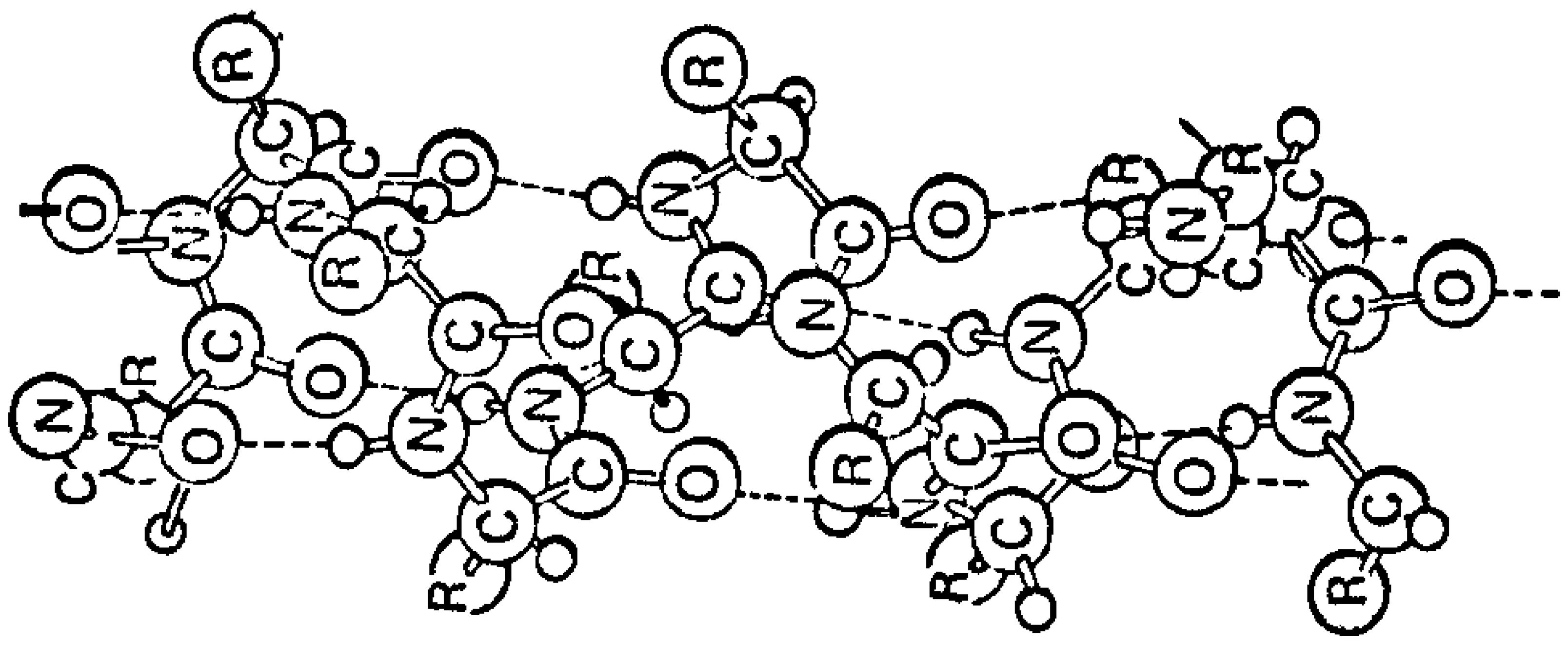
Project:

1. Construct a model of a hair. Use stacked polystyrene cups to give the overlapping cuticle structure. Cut away a section and fill with different colour modelling clay to distinguish cortex and medulla.

2. Obtain some small spheres made of styrofoam use these to build models of some of the molecules mentioned in this section. Toothpicks can be used to connect the model atoms together. Alternatively plasticine can be used instead of the styrofoam spheres. Consult a chemistry text to obtain information in order to enable you to build your models to scale.

Thus we can see that substances will differ depending on the number of atoms in a molecule, how the atoms are held together and how the atoms are arranged. It is not surprising that we have such a large variety of materials around us.

Hair has a very complex structure, it is composed of PROTEIN. You will have certainly have heard the term protein before, after all many of our foods are made of protein, and many shampoos today are advertised as protein shampoos. Proteins are a very large group of substances which have similar chemical structures. They are composed of the following elements, CARBON, HYDROGEN, OXYGEN, NITROGEN, while some also contain SULPHUR. The structure of protein molecules is very complex, they are among some of the largest molecules known. A diagram of a small section of a protein molecule is shown below.



There are many different kinds of protein, and hair is composed of a protein called KERATIN. We need not concern ourselves with the chemical structure of keratin.

We can test a substance for the presence of protein by the BIURET test. If the substance you are testing is a liquid, add about ten drops of a strong sodium hydroxide solution, then add one or two drops of a 1% copper sulphate solution. A purple colour indicates the presence of protein. If the substance you are testing is a solid, boil it in some water for a few minutes, and then perform your test. Note Take care in handling the sodium hydroxide. Wash your hands afterwards. Test the following substances for the presence of protein. Hair, egg white, egg yolk, cheese, flour, fish, milk.

Record your observations below. Which substances contain proteins?

Recycling of Atoms

Another quick test that is often used to identify proteins is to burn a sample, and note its characteristic odour. When the substance burns it is evident that many changes take place, let us try to see what happens to just one of the elements in protein.

Burn a bunch of wool, hair silk or nylon in a shallow tin can. Hold a test-tube over the flame for 1 minute. Place your thumb over the mouth of the tube. With your thumb removed, quickly pour 30-40 ml. of limewater into test tube. Shake. Write down your observations.

Limewater turns milky when it dissolves carbon dioxide. Where did the carbon dioxide come from?

We have already noted that the substance from which hair is made, protein, consists of atoms of carbon, hydrogen, nitrogen and oxygen. Where do these atoms come from and where do they go to? One of the most important principles in science is that of the conservation of matter. This was formulated by Lavoisier as far back as 1774, and in simple terms states that matter can be neither created nor destroyed. Now in the modern view we know that in fact mass can be converted into energy and vice-versa. However, this is such an unusual event it only occurs in extreme circumstances, such as the atomic bomb or the interior of the sun. In considering the life cycle of a hair the law of conservation of matter applies. So what happens to the atoms that make up a hair? They are simply converted from one substance to another.

Let us imagine that your hair is cut, and the hairdresser burns your hair. The carbon atoms in the hair combine with oxygen to form carbon dioxide, a gas, which is found in small quantities in the air. The carbon dioxide molecule may move around in the air for a long - long time. After a time the carbon dioxide molecule with our original carbon atom in it is taken in by a plant in order that the plant can manufacture its own food. This process is called photosynthesis. The plant may well die and be broken down by bacteria in the soil, but in this case we will imagine the plant was grass and the grass ends up being eaten by a cow. Eventually the cow finds its way onto your plate for dinner and so our original carbon atom finds its way back into your body. Once in your body it may well be turned into protein, maybe not hair protein but any one of a large number of proteins that the body uses.

CARBON DIOXIDE

HAIR

COW

BODY

GRASS

Connect the diagram above by arrows to show the cycle just described. One part of the cycle is called a FOOD CHAIN which do you think it is? Draw it below.

It is unlikely that you would absorb in your food a carbon atom that had previously been part of your hair, why?

The cycling of atoms, as described above for carbon takes place all the time in nature. Remember, matter is neither created nor destroyed. The cycles, may be very complex, far more so than was described here, but the atoms that make up your body have been in existence since the universe was created. Passing from one substance to another in endless cycles. An atom in your body may well have been a part of John Cabot once upon a time.

Assignment:

In this section you found that we can test for carbon dioxide using limewater. Our bodies "burn" food to produce energy, and one waste product is carbon dioxide. Design an experiment to show that you produce carbon dioxide as a waste product. Note it is not enough simply to blow through a solution of limewater. Why?

Project:

Consult magazines and books to find information on the care of hair. What general principles underlie the care and promotion of growth of healthy hair.

III. GROWTH

We have already seen that hair is a substance called protein, and in a general way we have seen how hair is produced by the body. In this section we will consider some factors about the growth of hair How fast it grows, different types of hair, baldness, hair colour, and other topics related to the growth of hair.

Hair and Cells

If you examine the back of your hand carefully with a hand lens, you will see that each hair appears to grow from a small indentation. This is the end of a tube, the follicle, in which a hair grows. The hair is a product of a deeper layer of the skin, the dermis. The dermis consists of living cells. As the cells reach the surface they die and produce the protein, keratin, which forms the basis of the outer skin layer, hair, nails and other skin growths.

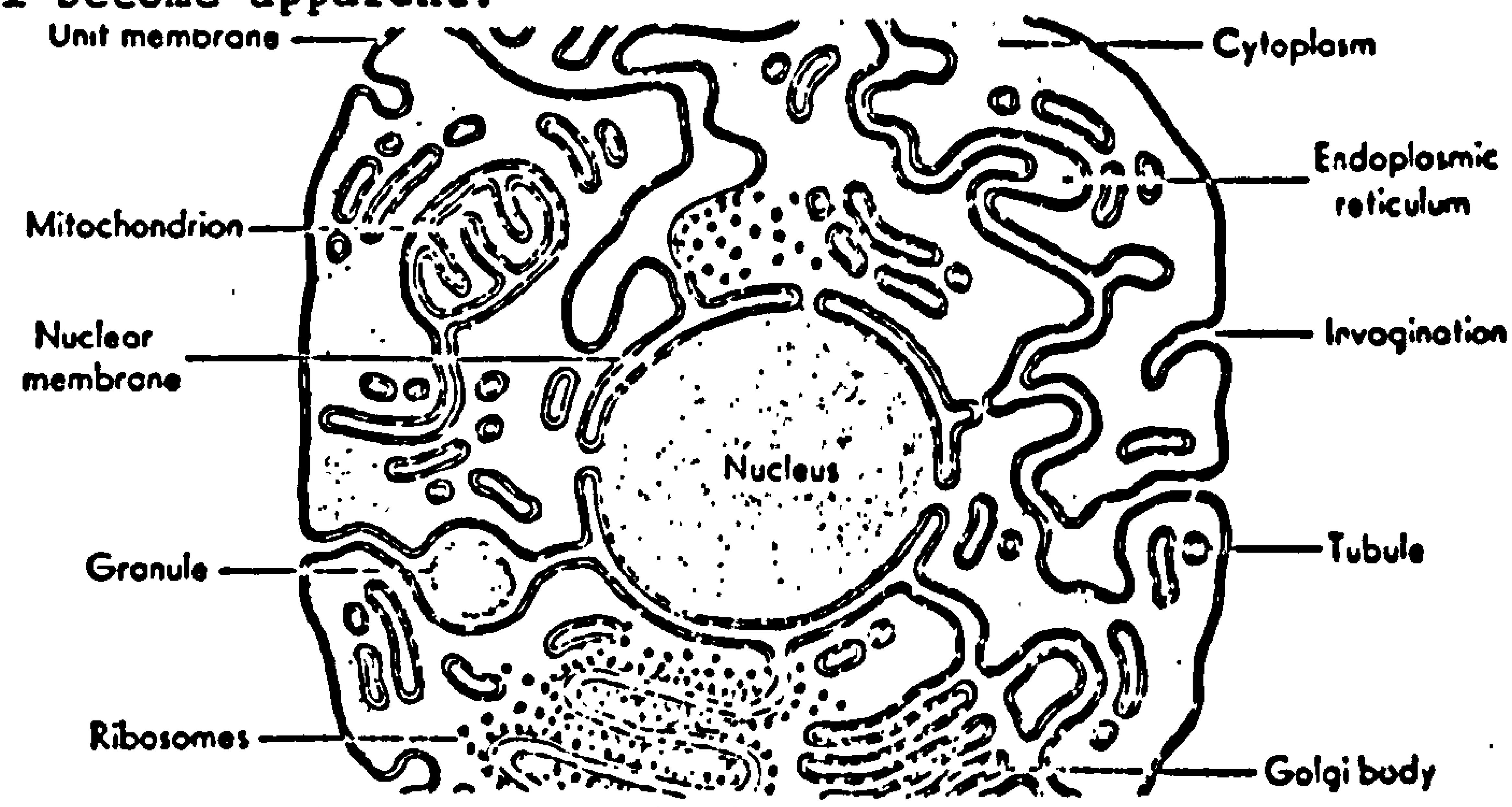
We have noted that the hair and outer skin layers are the product of cells which die. What do we mean by cells? And can we see them?

Nearly all living material is made up of basic units called cells. A cell is the smallest unit that still displays the characteristics of life. These were first observed in a piece of cork by Hooke in 1665. Not all the cells are the same shape since the shape depends in part on the job that they do. Let us look at some cells from our own body.

Your teacher will show you how to prepare some slides to enable you to look at cells from living materials. You should be able to see some cells from your own bodies as well as cells from other sources.

On the next page describe the procedure that you used for preparing the slides. Sketch your observations. Your teacher will also show you some pictures of cells which have different functions. Include sketches of these in your book.

You will note that not all cells look the same, and in fact, you will see comparatively little detail. If a scientist extends his powers of observation by using an electron microscope, many more parts of a cell become apparent.



Although cells may be very small they are very complex, for example, they must have mechanisms which let in substances the cell needs, and keep out substances that would harm it. They have the ability to manufacture proteins they need for a variety of reasons. They also contain all the information that enables the cells to reproduce themselves exactly.

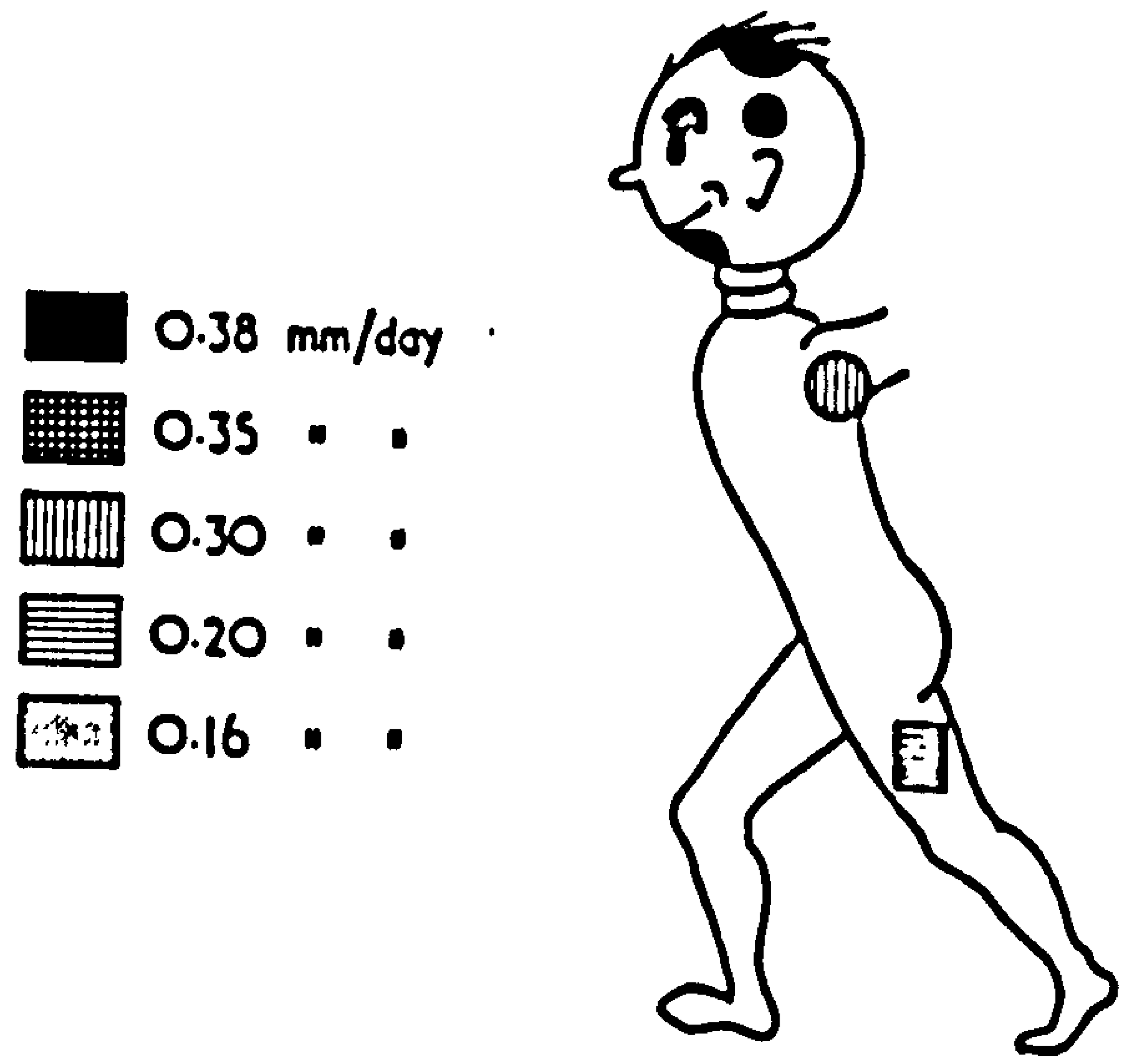
GROWTH AND DISTRIBUTION OF HAIR

Now let us return to hair, which is produced as cells die and move towards the surface of the skin. Hair grows very slowly, and in fact, it starts growing in humans before birth. A fetus has its head, the forehead as well as the scalp, covered with hair and as it gets nearer to birth it loses hair until its hairline is well established. In fact, this process carries on for a while after birth. Those of you with younger brothers and sisters may have noticed that babies are often hairier at birth than later. Human hair grows very slowly; too slow for us to measure on the spot.

Human hair grows at the rate of about 1/3 of a millimetre a day. On the scalp it may attain a length of 4 metres while on other parts of the body its growth is limited. Hair growth is generally a matter of alternate growing and resting. In man in any given area some hairs are growing and some resting. However, in some animals such as dogs the process is seasonal and the animal will shed its coat as new hairs grow. If you own a dog you will certainly be aware of this.

It has been established that hair of all types on all animals show a definite growth pattern. Briefly, when a hair reaches the end of its growth, the hair follicle goes into a resting stage, known as telogen, and the hair becomes a "club" hair. The deeper cells of the follicle degenerate, so that the "club" is only connected to the surrounding skin by a strand of cells called the "hair germ". After a resting period of variable length, depending on the site of the body, and age of the individual, the cells of the "hair germ" become active. They undergo multiplication and differentiation, so that the deeper part of the follicle is reformed. This stage is the growth stage, called "anagon", which continues until a new hair becomes differentiated, and as it moves to the surface, the old "club" hair is dislodged and shed.

The growth rate varies with the individual and the region of the body - the <u>average</u> rate being somewhere around 0.3 mm. per day. The character of the hair on various parts of the body changes mainly as a result of hormonal influence - See Hormones. The kind of hair on the body varies with the age of the individual. The diagram on the next page shows the rate of replacement of hairs plucked from different regions of the body.



The rate of replacement of hairs plucked from different regions of the body. (Diagram based on figures published by Myers and Hamilton, 1951.)

The length and type of hair found in man is shown in the table below.

MORPHOLOGICAL TYPES OF HAIR IN MAN

	Type	*Metric Characteristics (Normal Range)*	*Description*
I.	Head hair	100 to 1000 mm. in length cross section diameter @ 25 to 125 μ	Relatively small root, tapered tip, usually medullated, all variations in form known.
II.	Eyebrow and eyelash hair	Average length about 1 cm.	Curved, coarse smooth with punctate tip and large medulla.
III.	Beard and moustache hair	Length 50 to 300 mm.	Larger root than I, more complex medullary processes, more irregular structure, blunter tip.
IV.	Body hair	3 to 60 mm. in length	Fine long tip, irregularly medullated, irregularities in structure; may be banded or tipped. All forms and structural types.

Assignment:

Since hair grows so slowly it is difficult to measure the rate of growth. However we can make a rough estimate of the rate of growth of hair. You may know a young child who never has had their hair cut, or even a classmate! Measure the length of their hair to the nearest millimetre, and from the knowledge of their age calculate the daily rate of growth. Observe which hair is the longest, does hair appear to grow at the same rate all over the head?

Colour and other genetic factors

Probably one of the most interesting characteristics about hair is colour. If you look around you at your classmates you will soon see the variety of colours that exist. The colouring matter, PIGMENT, of hair is MELANIN, which is contained in the cortex. There appear to be four types of pigment black, yellow, red, and brown. These pigments are present in human hair in varying amounts, and hence we have the wide variety of colours that we see.

Hair colour is a hereditary trait that is passed on from our parents. Hereditary traits are carried by GENES, which are found on small structures called CHROMOSOMES located in the nucleus of a cell. In a later module we will take a closer look at the mechanism by which traits are transmitted.

Construct a pedigree for your family for each of the following characteristics for as many generations as possible - ask parents and grandparents about the characteristics of their parents and grandparents.

A family pedigree should be constructed showing:

(i) Hair Colour
(ii) Hair Curliness
(iii) Baldness

Your teacher will illustrate how this is to be done.

Start with your brothers and sisters, and place them in one line at the bottom of the pedigree.

Add the characteristics of your parents, and then add their brothers and sisters.

Now add the information for their parents (your grandparents) and include as many of their brothers and sisters as possible.

If possible, add any of your great-grandparents that you know about, and indicate their brothers and sisters.

The final step is to work down again, putting in details of your parents, brothers' and sisters' children, and so on:-

NOTE: Children who died in infancy, or individuals who you know existed, but who you have no information about, should be shown by the correct sign with a diagonal line drawn through it.

BALDNESS

There are a number of causes of baldness, the most common of which is due to an inheritance of baldness genes, much as in the case of hair colour. There are many more bald men than women. If you are a male and your father was bald, then there is a 50-50 chance that you will become bald. If both your parents were bald your chances of becoming bald are much greater.

Some people find bald men attractive, many do not. Since being attractive is important to most people, the topic of baldness is of interest to both men and women. We will examine the cosmetic role of hair, or the lack of it in more detail in a later section on the Ornamental Use of Hair.

In this section we will examine two aspects of baldness. The first relates to printed statements made about the psychological effect of being bald. The second is a first hand report of the psychological and social effects experienced by a man who lost all of his hair at the age of eleven.

Although most of us take much of what we see on television with a grain of salt, we tend to regard articles in printed form in newspapers, magazines, and especially text books, as the absolute truth. We somehow believe that if something managed to get into print, someone must have made sure that it was correct. One of the things you will need to be able to do when you leave school is to analyze written statements more critically. Does the author have all the facts? Is there more than one way to interpret these facts? Is he biased for some reason? Does he have a special reason for wanting you to believe what he says?

On pages 37-40 is a reprint of an article, Baldness Is Always Having to Say You're Sorry, which appeared in a recent issue of Weekend Magazine. It is a fascinating article in which the author makes many interesting statements one of which is: "there are happy men and there are bald men, but there are no happy, bald men". At a time when male baldness is on the increase, this article calls for close examination.

Read the article carefully at least twice, and consider the following points: $\boxed{\text{T12}}$

1. In what way is Dr. Herlich's information based on a biased sample?

2. How can you test the statement: "There isn't a bald man anywhere that isn't troubled by his condition"?

3. How acceptable are Dr. Herlich's "explanations"?

4. Can you think of examples that contradict Dr. Herlich's claim that men want to be hairy?

5. How many unsupported or dogmatic statements can you find in the article?

6. What valid points are made in the comments:

"BALDNESS IS ALWAYS HAVING TO SAY YOU'RE SORRY"

Bald-headed men are insecure individuals who hide their hangups by wearing flashy clothes, driving fast cars and gravitating to the most gorgeous and most sought-after girls in town.

And don't believe the old myth that bald men are sexier than other males. They're not. They just try harder.

The information comes from a Montreal physician named Samuel Herlich who has interviewed some 10,000 bald and balding men in the last 10 years and who may well be one of the country's leading authorities on the habits of the hairless.

"There are happy men and there are bald men," he says, "but there are no happy, bald men."

Dr. Herlich, a 44-year-old general practitioner who is not in danger of going bald himself, specializes in hair transplantation with Montreal surgeon Dr. Henry Korman. (Weekend Magazine, March 30, 1968) The procedure is a relatively simple one. Hair is removed from the back of the head, where it continues to grow in spite of advancing years, and implanted on the bald area.

Dr. Herlich has gotten to know his bald men pretty well because in addition to the usual medical questions, he puts them through an exhausive personality questionnaire.

The doctor won't operate on just anyone. He is concerned about the psychological aspects of every case. The unhappy man who thinks that a new crop of hair will assure him of an exciting new life, for instance, may well be a poor personality risk - and hence the probing questions.

Ten years of delving deeply into the business, social and sexual life of prospective patients has convinced Dr. Herlich that bald men are a breed apart. His findings, he says, have been confirmed by an Ottawa psychiatrist friend, Dr. Erwin Koranyi.

"Bald men are different from other people," says Dr. Herlich. And he has worked out a profile of the balding man which, he says, sets him apart.

In business, he says, the man with no hair is ambitious and aggressive. He likes to give orders instead of taking them and generally makes a better boss than employee. Invariably he prefers to be in business for himself.

The explanation for this lies in the fact that most men consider their baldness to be a defect which can only be overcome through hard work and success.

"There isn't a bald man anywhere who isn't troubled by his condition," Dr. Herlich maintains.

Only the bald know how damaging their state is to the ego, he says. It can affect their lives profoundly.

He goes on: "Baldness is always having to say you're sorry. Bald men go through life apologizing for themselves and trying to compensate for their deficiency."

Dr. Herlich's profile sets the bald man down as usually kind and considerate. He is particularly so with someone who is ill. Explanation: the bald man can understand sickness because he considers that he, too, has an affliction. And since he suffers no pain from his baldness, he can afford to direct his sympathy to another.

It is in social and sexual situations that the bald man is perhaps most aware of his condition, the doctor has discovered.

"It's the old business about man being descended from the ape," he states. "Man thinks that, like the ape, he, too, should be hairy. He associates hair with strength. The minute a man sees he's losing his hair, he gets frightened. He thinks he will also lose his virility. He says to himself, 'I'm a weakling.'"

The bald man buys a big car, or an expensive sports car, to draw attention away from his head. He wears sharp clothes for the same reason. He hopes people will look at his suit instead of his smooth dome.

Girls provide a double situation. He reasons that if his girl is beautiful enough, people will look at her instead of him. Again, an attractive girl will give him a feeling of being virile.

"Look around at a cocktail party," the doctor says. "The bald man always gravitates to the best-looking girl. Other men may find a woman interesting and attractive regardless of age. Not so the bald man. He may be 60 but he'll pick the young chick every time."

Loss of hair can be a traumatic experience for men and over the years they have tried many cover-ups. Some wear toupees. Some have had new strands woven onto their own hair at the back of the head. Others have opted for a procedure whereby a length of wire is stitched in and out of the scalp, allowing loops on which hair can be woven.

None of these procedures works very well, the doctor says. From a medical point of view, he thinks the bald man really has only two choices. He may elect to remain bald, or else he has a transplant.

When Dr. Herlich selects a man for transplant, he is confident of success. The man concerned may be reasonably assured that his baldness will be a thing of the past.

Dr. Herlich has followed up his patients over the years and he says that there have been some remarkable psychological changes in those operated on. The basic change, of course, is that confidence has replaced insecurity in many men.

"The bald man who finds new hair growing is a very thankful man," Dr. Herlich says. "And why not? He figures he has been cured of an illness."

GROWING UP BALD

by

Lionel Mendoza

I was born on July 10, 1944 in London, England. I lost my hair, (eyebrows and eyelashes as well) due to a disease known as "ALOPOECIA TOTALIS". The best way to describe the effect on me is to divide my life into two periods, my teens, and twenty onward.

Teens (eleventeen - nineteen)

Losing your hair at the age of 11, is to say the least, unusual. Being bald, however, gives you certain advantages. For example, when I wanted to see a restricted movie no-one questioned my age. When I wanted to have a drink in a bar I could (within reason). Probably the greatest advantage is not having any hair to take care of. No haircut, no need for a comb, hair cream, shaving, etc.

Certainly there were disadvantages. Kids are not always kind and they tended to pick on me because I was bald. Since I was bigger than most of the kids this soon stopped. I found adults following me down the street as if I were some kind of freak. I can remember one particular incident when one lady followed me as I was walking to catch a bus. In spite of me staring at her she just continued to look (stare) at me. I found that the only solution was to talk to a passing policeman and inform him that there was a woman on the other side of the road who seemed to have lost her glasses and could he please help her. She never followed me again.

There were some major negative effects. I went through a stage when I did not want to go out of the house. Towards the end of my teens I went through another stage when I wanted to wear a wig. I did, in fact, wear a wig for about a year, but then concluded that this was really stupid.

With regard to baldness in your teens I should say that you either sink or swim. You can easily use baldness as an excuse for not going out, for not meeting people, etc. During this period you certainly go through various stages of depression, but in my case, all were short lived. Whether baldness has any lasting effect is purely a personal thing. With help from your friends you can find that it is really no disadvantage at all.

Twenties Onward

I have separated this period since I found that at the end of my teens I really forgot that I was bald. By that I mean that I can think of no disadvantages to being bald from the time I was twenty. The only slight disadvantages are that in the winter I have to wear a hat otherwise my head gets extremely cold (similarly I get sunburn easier). Also hair absorbs moisture from sweat so that I tend to sweat more openly when playing squash. Other than these minor annoyances I can think of no other disadvantages.

EVOLUTION AND HAIR

Scientists have every reason to believe that man is becoming less hairy. This progression towards baldness is an evolutionary trend. Just what do we mean by evolutionary trend? Well, in very simple terms, evolution as suggested by Charles Darwin depends on two points:

1. That in any group of organisms a variety of characteristics exist. This is self-evident, after all, Examine your classmates. They differ from you. Some are taller, shorter, fatter, etc.

2. A characteristic which gives an animal an advantage in adapting to its environment becomes more common in the group in successive generations, as favoured individuals can compete better.

Thus the duck has a distinct advantage in having webbed feet for swimming. Darwin would have explained this by saying that among the ancestors of ducks some were born with webbed feet (mutation). These birds had an advantage in obtaining food and escaping from predators, thus they survived better than the birds without webbed feet. Thus the frequency of the gene for webbed feet increases in the population and more webbed-feet ducks appeared.

Thus a trait appears or disappears according to the theory of evolution as long as it conveys a positive advantage. However, although scientists agree that man is becoming progressively less hairy, they cannot agree what advantage this gives him. What advantages do you think it would be for a man to have a smooth skin instead of a hairy one?

Assignment:

1. Find an article in a magazine or newspaper, read it and analyse it in a similar manner to the article you studied in this unit. Indicate any dogmatic and any unsubstantiated statements that are present.

2. An important factor that we have not considered in this section is the influence of hormones on hair growth. What is a hormone? Find out some examples of their importance to humans. Find out what hormones influence hair growth.

Project:

The distribution and length of hair in dogs varies from breed to breed. Examine as many breeds of dogs as you can, and describe the distribution of hair in their coats. Note any factors that you think could influence the growth of hair. e.g. Whether the dog lives in or out of doors.

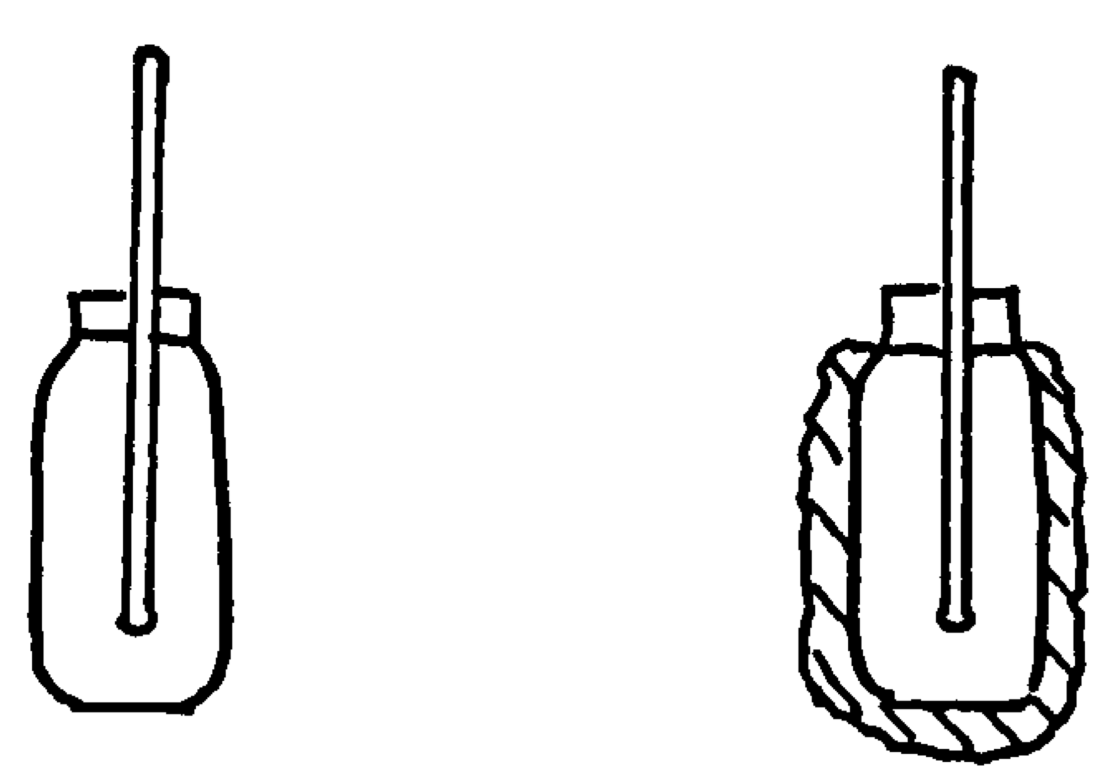
IV. FUNCTION

In an earlier unit we noted that scientists believe that modern man has less hair than did his early ancestors. However, we have retained some hair and it has many important functions. These can be grouped under the headings, protection, warmth and adornment. In this section we will be mainly concerned with the insulating effect of hair, although we will also consider some other aspects of the function of hair as well.

Heating and Cooling

One of the important functions of hair is to prevent heat loss. For warm-blooded animals living in cold climates the conservation of body heat is a significant problem if the animal is not able to maintain its body temperature it will die. In this activity you are going to investigate the effect of hair on heat loss.

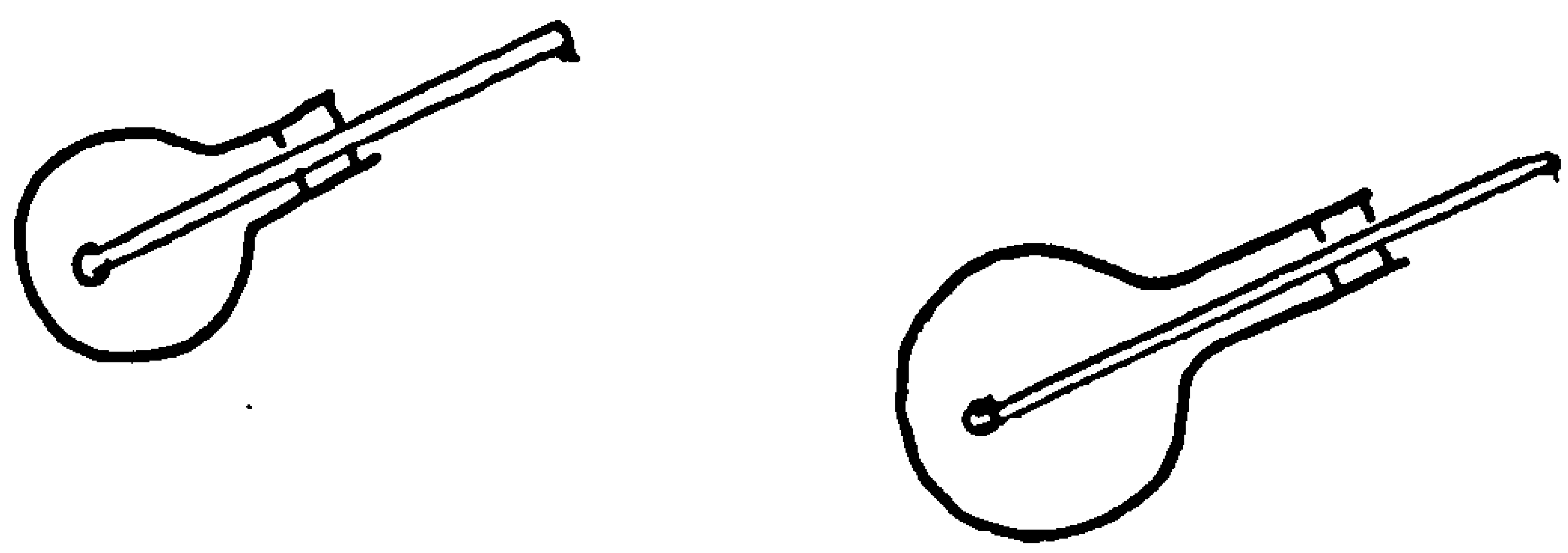
Instead of using animals you will use containers filled with warm water surrounded by cotton wool.



Now before you do the activity it is important to think just what it is you wish to investigate. In this case you want to examine the effect of the insulating material on the heat lost by the container. These are the EXPERIMENTAL VARIABLES. The experimental variables are what we expect to change in the experiment. All other factors should be kept constant. In the space below write down as many factors as you can that might affect the heat lost by your experimental "animal".

Having identified the factors you wish to keep constant design an experiment to investigate the problem. Make certain that in designing the experiment you CONTROL the unwanted factors you identified. Put your results in a table, and plot a graph of your results, and note any conclusions you can draw from them.

You have seen that hair will affect the amount of heat lost by an animal, however it is not the only factor to consider. The following table of results is from an experiment carried out with two round-bottomed flasks, one 100 ml in volume and the other 500 ml in volume. Both flasks were filled with nearly boiling water, and the temperatures were recorded every 2 minutes.



LARGE FLASK		SMALL FLASK	
Time	Temp.	Time	Temp.
0 min.	66°C	0 min.	75°C
2 min.	65°C	2 min.	70°C
4 min.	65°C	4 min.	66°C
6 min.	64°C	6 min.	64°C
8 min.	63°C	8 min.	62°C
10 min.	62°C	10 min.	60°C
12 min.	61°C	12 min.	58°C
14 min.	60°C	14 min.	56°C

Which flask cooled the fastest?

If we think of the flask cooling, it loses heat through its surface. The larger the surface the more efficient it will be at losing heat. However the larger the volume, then the more heat will be contained in the flask in the first place. The rate at which the flasks lose heat will depend on these two factors.

The two flasks used in the experiment had surface areas of 100 cm. and 300 sq. cm.

Thus the ratio of surface area to volume for each flask was:

flask A $\frac{\text{surface area}}{\text{volume}} = \frac{100 \text{ sq. cm.}}{100 \text{ ml.}} = 1.0$

Complete the calculation for flask B.

Which flask has the larger surface area to volume ratio?

Does this make sense when considering the results of the experiment?

If you were to take a series of objects such as cubes and measure the surface area and volume and calculate the ratios, you would find that as the cubes get larger, then the ratio of surface area to volume becomes smaller. Thus small objects tend to lose heat more quickly than large ones.

On the basis of the experiment you performed and the one you have just discussed, answer the following.

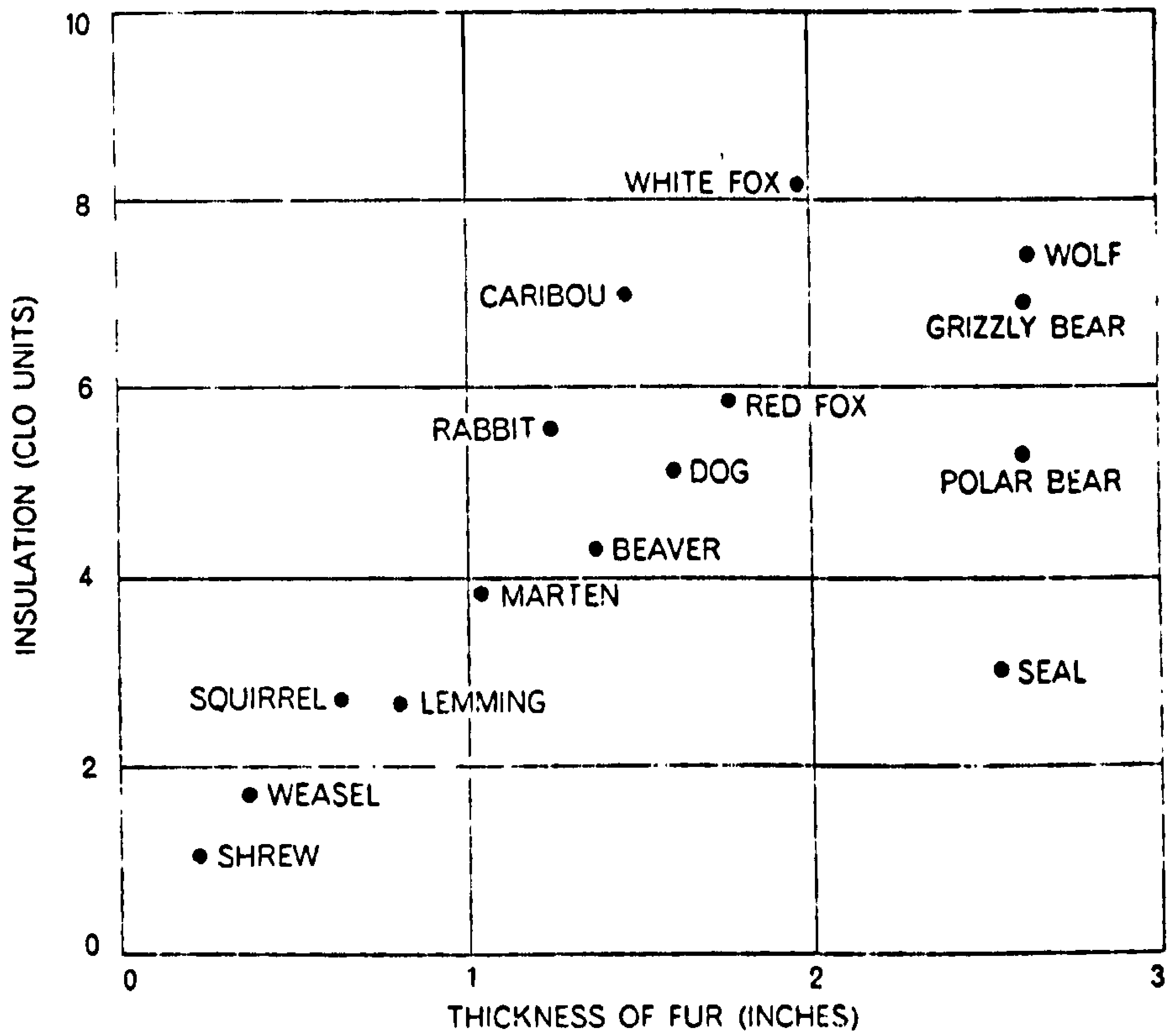
a. Why cannot babies tolerate the low temperatures adults can?

b. Why are whales and seals (both warm-blooded creatures) large?

c. Why are warm-blooded animals that live in the Arctic larger than those that live in warmer climates?

Assignment:

The graph below is adopted from "Adaptations to Cold," Lawrence Irving. January, 1966, pg. 226. The graph shows the different insulating effects of the fur of different animals.



INSULATING CAPACITY of fur is compared for various animals. A "clo unit" equals the amount of insulation provided by the clothing a man usually wears at room temperature.

1. How many "CLO" units of insulation does a shrew wear?

2. What is the thickness of a dog's fur?

3. The seal has comparitively thick fur, but small insulating capacity. What other protections against cold does the seal have?

4. Compare the fur insulating capacities of a dog and rabbit.

<u>NOTE</u>: A dog is a bigger animal. It, therefore, has lesser surface area relative to its weight. Thus it loses less heat per weight. Also its habitat is probably warmer since domesticated. A rabbit's fur though not so thick must have better insulating properties. Also must be more active and eat more per unit weight than a dog.

5. Compare the rabbit with the caribou. The latter has greater insulating capacities and also thicker fur. Much thicker? Speculate on how difference in insulating capacity may affect behaviour of the two animals--or vice versa.

(a) Do they live in same area?

(b) Are they both active to the same degree?

(c) The rabbit is smaller, does it need the same insulation? Less? More?

(d) Does the latter answer help to explain (b)?

6. Compare rabbit with beaver--roughly same size? Yet beaver's insulating capacity is lower.

(a) Does this tell us something about beaver's habitat?

(b) Is its fur thicker? Comment on nature of its fur compared to rabbits.

Animal Hair and Sensitivity

Although man makes little use of hair, many animals use hair as a sensory organ. Most hairs in a mammal's skin have nerves around them so if the hair is touched the animal detects it.

Close your eyes and see whether a friend can touch your hair without your knowing it. Describe below what you observe.

Remember each hair is surrounded by nerves, how do you know that hairs do not contain nerves?

Many animals make use of hair as a sensory organ, e.g. squirrels have hair on their abdomen which is sensitive, so that they can feel their way as they run along the bark of the tree. Many mammals have long sensitive whiskers around their muzzles.

Observe the whiskers of a cat or a dog and draw a sketch of what you observe.

Noctural animals have particularly well developed whiskers. What advantage does this give them?

Ornamental use of Hair

For people the main function of hair is ornamental. We spend a great deal of time and money on our hair. To someone visiting us from another planet our behaviour must seem a bit bizarre.

On the one hand we go to great length to get rid of hair from certain parts of our body (face, legs, and underarms) and at the same time we worry a great deal about the loss of hair from the top of our head. If our visitor from space were to watch our television, he would become convinced that the greatest dangers to our species (next to bad breath) would be dandruff and underarm odor.

Probably the best way to get a fairly accurate estimate of the time and money spent on hair is to take a student survey. As a class project you can design and print your own questionnaire to be given to other students in the school.

In the space below list some of the questions you think should be asked of other students.

The data received from your questionnaire can be graphed to indicate the relationships between such factors as age, time spent, sex, money and so forth. Your teacher will discuss with you the general approach to take.

V. PHYSICAL PROPERTIES

So far we have looked at hair from the chemical and biological points of view. In this unit we will consider some of the physical properties of hair. How thick is it? How strong is it? How does water affect it? We will consider these and other questions, and you will be expected to design several experiments to find the answers to these questions.

Size of Hair

As you know from simple observation the thickness of your hair is very small. How small? One way to find out would be to use a device called a micrometer which measures very small distances accurately. Unfortunately, micrometers are very expensive and it would not be practical to have enough for every group of students. We can however, estimate the size of a hair using a microscope and transparent plastic ruler. Many of you will have such a ruler with a scale marked in millimetres. Examine a hair under the microscope mounting it on top of the millimetre scale. Estimate the diameter of the hair to the nearest 1/10th of a millimetre. Use this technique to answer the following questions.

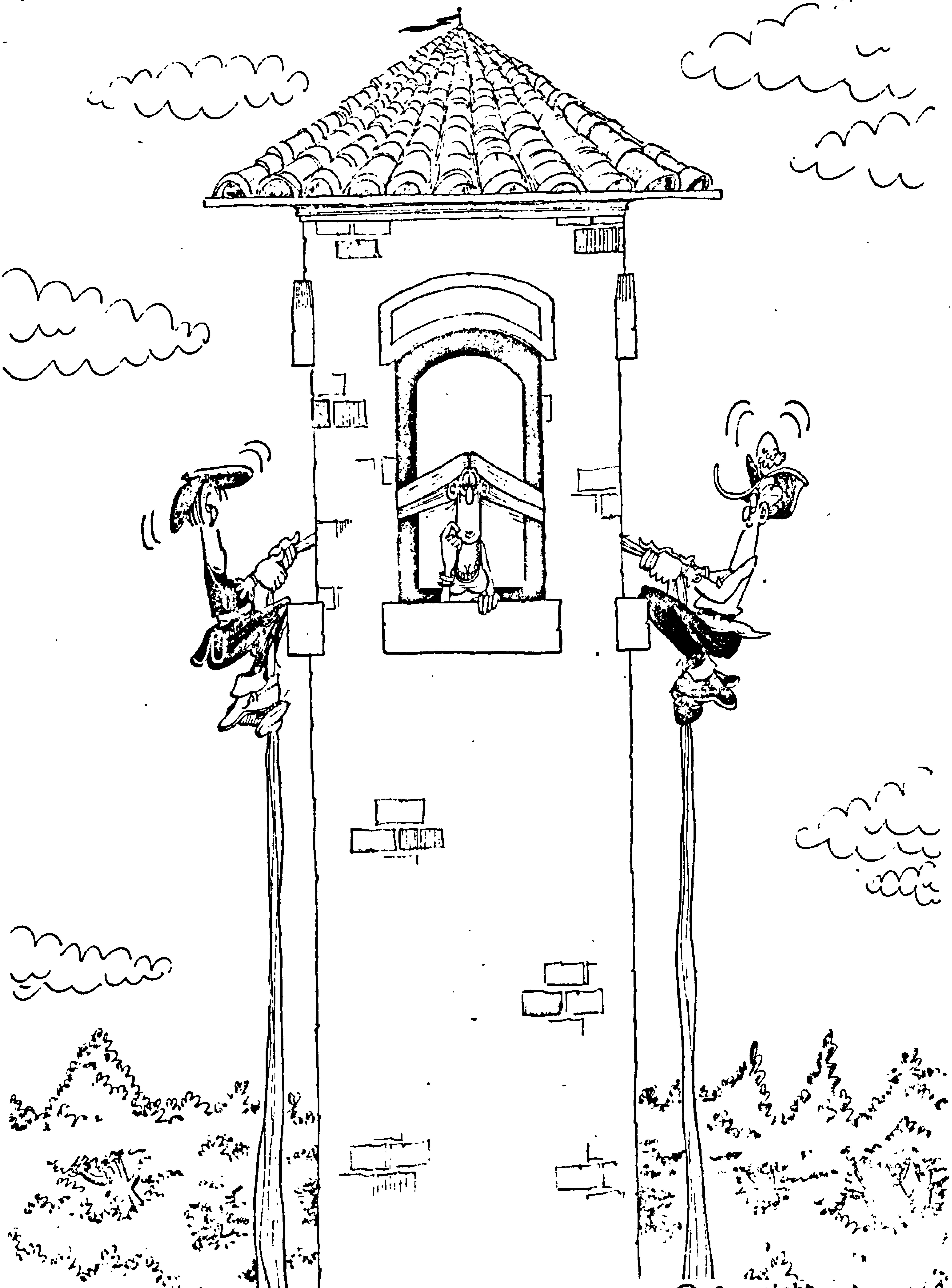
1. Is hair from different parts of the head the same thickness?

2. Does hair of one colour appear to be thicker than hair of another colour? (You may have to compare results with other class members.

3. Is a hair the same thickness all the way along its length?

Record you results below.

Retain several long hairs of known length for the next section.



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Strength of Hair

How strong is human hair? This is an intriguing question. Some of the photographs and drawings that introduce this section suggest that it might be quite strong. Is it as strong as fishing line? How about a piece of thread? Is all the hair in your head strong enough to support you? The only way to find out, of course, is to experiment with various samples of hair. It will be interesting to compare your results with those of other students in the class.

Before you actually begin experimenting you will have to answer one question and suggest some possible answers to a second question.

First you must answer the question:
"WHAT DO YOU MEAN BY THE STRENGTH OF A PIECE OF HAIR?"

By strength do you mean the weight a piece of hair can support before it breaks? Do you mean how many times it can bend before it breaks? Perhaps you can think of other meanings.

Once you have decided what you mean by the strength of a piece of hair, you need to decide just how this will be measured. We want to make use of equipment that is as simple as possible. We do not have weights marked off in ounces or grams, but we do have small lightweight containers, salt, sand, water and washers. Does this suggest a method of measuring strength? Describe below as carefully as you can the procedure for measuring the strength of a piece of hair.

After you have described this method, you need to consider some possible answers to the question:

"WHAT FACTORS AFFECT THE STRENGTH OF A PIECE OF HAIR?"

We say possible answers because you may not be able to think of all factors, nor may you be able to guess just how each factor affects hair strength.

Suppose for example that you think the length of hair has an effect on its strength. Is a piece of hair 20 cm long twice as strong, half as strong, three times as strong, etc., as a piece of hair 10 cm long? There is no way to know for sure unless you conduct an experiment, but it is important to make a guess beforehand. Otherwise you will not know what to investigate or what to look for. Make a list below of all factors that you think might affect the strength of hair.

One final point before you get started. You cannot investigate the effect of all of the factors you have listed at the same time. If you think both length and diameter affect the strength of hair, you cannot change both at the same time, because if you do you will not know which one is having what effect.

What then must you do?

Assignment:

The cartoon on an earlier page, shows two men climbing up a tower, by using a lady's hair.

a. From your experiments to measure the strength of hair do you think that this is possible? Consult the article "Joe's hair" for any additional information needed. Assume each man has a weight of 80 kilograms. Show your calculation.

b. From your previous work on the rate of growth of hair, calculate the lady's age. The tower is ten metres high.

Elasticity of Hair

In the last activity as you measured the strength of hair, you may have noticed hair stretches. If you take a hair between the fingers of one hand and stretch it, by running the fingers of the other hand along its length, you will notice it stretching and curling. After a while it will return to its original length, it appears then that hair is an ELASTIC material.

Design an experiment to investigate the elastic nature of hair. You can reasonably expect the length of the hair to increase as the weight you add to it increases. However how does it increase? Does it increase proportionally to the weight? By this we mean is the increase in length doubled as the weight is doubled, tripled as the weight is tripled, etc. The experiment you design should attempt to answer this question. Record your procedure and results below. Plot a graph and record your conclusions below.

In the preceeding activity you examined the elasticity of hair which was dry. Investigate the behaviour of wet hair. Does it stretch in the same way as before?

Hair and Humidity

As your past experiences might suggest, hair is quite sensitive to changes in moisture in the air. Of all the types of hair, human hair, is the most sensitive. What happens to your hair on very damp days? Why does your hair curl more on these days?;

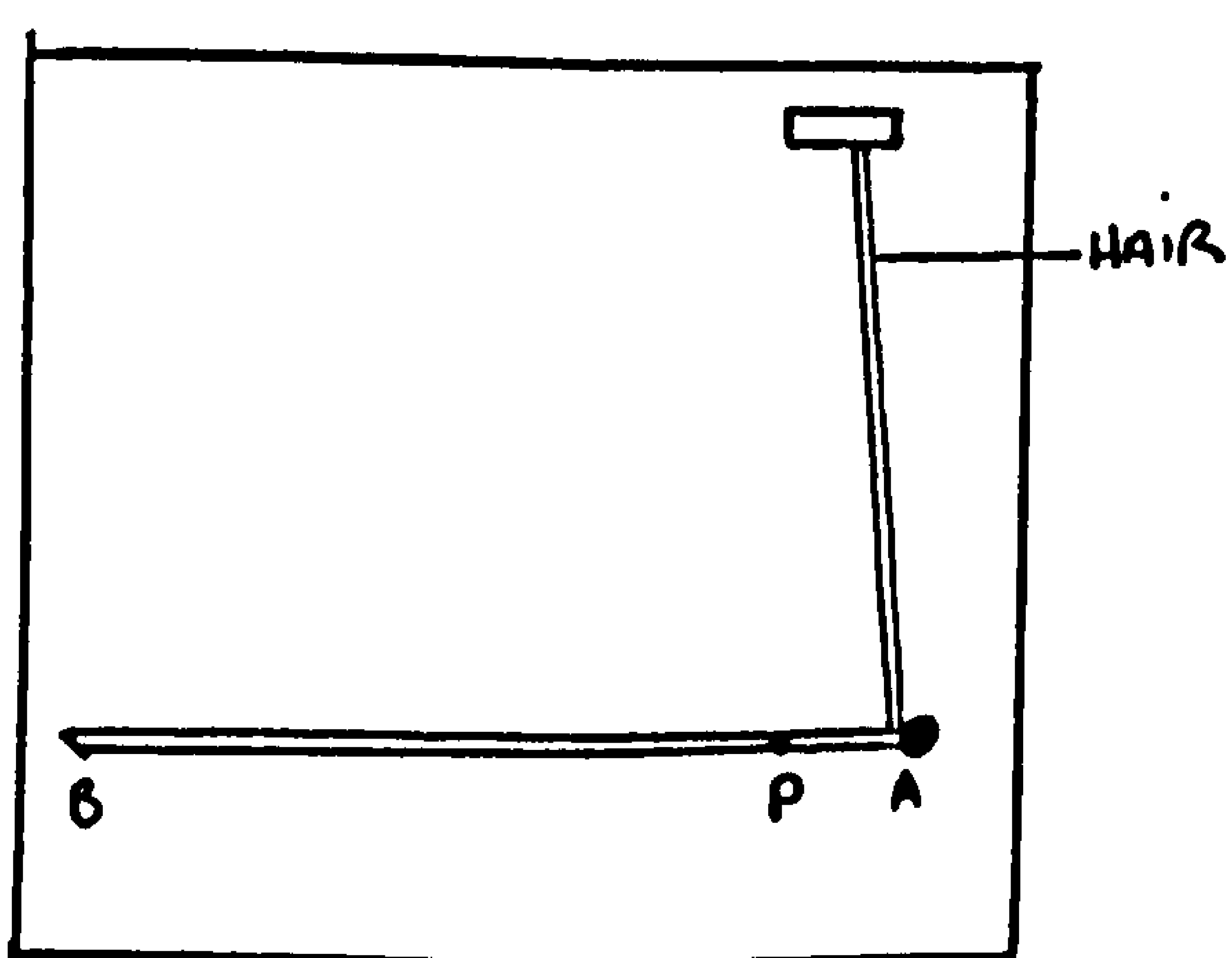
Air normally contains a small amount of water vapour. The maximum amount it can hold depends on the temperature. Thus warm air holds more water vapour than cold air. When air holds the maximum amount of water vapour it can it is said to be SATURATED.

On a day when the air contains a great deal of water vapour we feel lethargic and we consider the air to be humid. We measure the humidity of air by measuring the amount of water vapour present in a mass of air and comparing it to the amount required to saturate it. This is what we call the RELATIVE HUMIDITY.

$$\text{Relative Humidity} = \frac{\text{WEIGHT OF WATER VAPOUR PRESENT}}{\text{WEIGHT OF WATER VAPOUR REQUIRED TO SATURATE THE AIR.}}$$

Thus if the air contains 50% of the water vapour required to saturate it, then the humidity is 50%, and if the air can hold no more water vapour then the humidity is 100%.

To measure the weight of water vapour present in the air is very difficult, and as a consequence we use instruments which observe changes caused by a change in humidity. Human hair is so sensitive to changes in the humidity of the air that it is used to measure the amount of moisture in the air. Instruments which measure the humidity of the air are called HYGROMETERS. Below are the directions which enable you to construct a simple hair hygrometer.



Obtain a piece of stiff card 15" x 15" and a soda straw and two or three hairs at least 10-12" in length.

Fasten the straw to the card using a pin as shown. Make sure the straw is able to rotate freely around the pin. Weight the end A of the straw with a small piece of plasticine so that end A moves down. This will ensure that the hairs are under tension when you assemble the instrument.

The principle on which the instrument operates is that hair changes length as the humidity changes. As with any instrument that we use to measure we must CALIBRATE it. By calibrating it we mean we have to note its readings at a number of FIXED POINTS. In the case of the hair hygrometer we will use the humidity values of 100% and 0% as fixed points.

What fixed points are used by a thermometer?

Wet the two hairs and tape them to the card and straw as shown. Mark the position of end B of the straw on the card. This corresponds to a humidity of 100% and is one fixed point on the scale. Note it may help to give more accurate headings if you cut the end B of the straw into the shape of a point.

In order to obtain the other fixed point we must dry the hair. Enclose the hygrometer in a box containing a tray of calcium chloride. This is a drying agent, and will cause the hair to dry giving a humidity reading of 0%.

Divide the distance between your two fixed points into ten divisions, and mark the humidity values on the scale. Set your instrument in a safe place away from a draft. Note the changes in humidity and how they correspond to changes in the weather.

Electricity and Hair

First it is necessary to emphasize what we do not understand about electrostatics. For reasons not yet adequately explained, there is a force of attraction between electrons and protons. Also, this force acts at a distance, like gravity, and magnetism. To explain these three forces scientists have constructed a "Field Theory" which essentially says the space is influenced in a particular way by the presence of gravity objects (matter), magnetic objects, (moving charged particles) and objects containing electric charges.

Though we may not fully understand the phenomenon, we can explore some of its effects, in particular the effects of electricity on hair.

1. Take your comb (plastic, rubber, nylon) and place it near bits of paper. Write down your observations.

2. Now comb your hair (should be dry) and repeat (1).

3. Next suspend the charged comb by nylon or silk thread. Charge another comb similarly and bring it near but not touching the suspended comb. Write down your observations.

4. Repeat 3 with glass rods (test tubes are O.K.). Write down your observations.

5. Next suspend the charged comb again. This time use a charged glass rod. Write down your observations.

6. On the basis of what you have learned about electrostatics, explain observations 1 through 5.

7. Comment on the electrostatics of hair.

8. How many kinds of electric charges are there?

9. What can you say about (i) like electric charges (ii) unlike electric charges?

10. Try experiments with wet combs. Explain your observations.

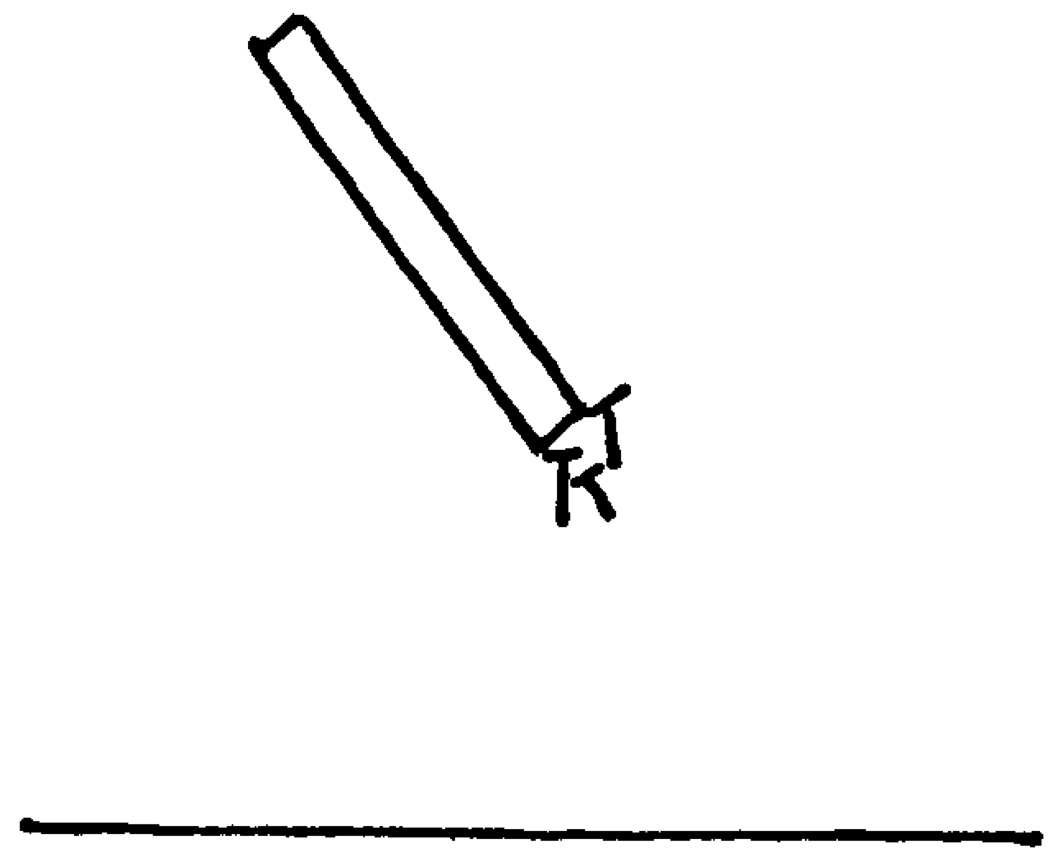
11 You have seen that a charged comb will exert a force on a piece of paper and lift it up. We can think of a force in simple terms as a push or a pull. This type of force is an electric force, and is of the same nature as that which holds atoms together. Other types of forces you may come across are magnetic and gravitational. In the experiment where you picked up the pieces of paper two forces were acting. What were they?

Which of the two forces was the greater?

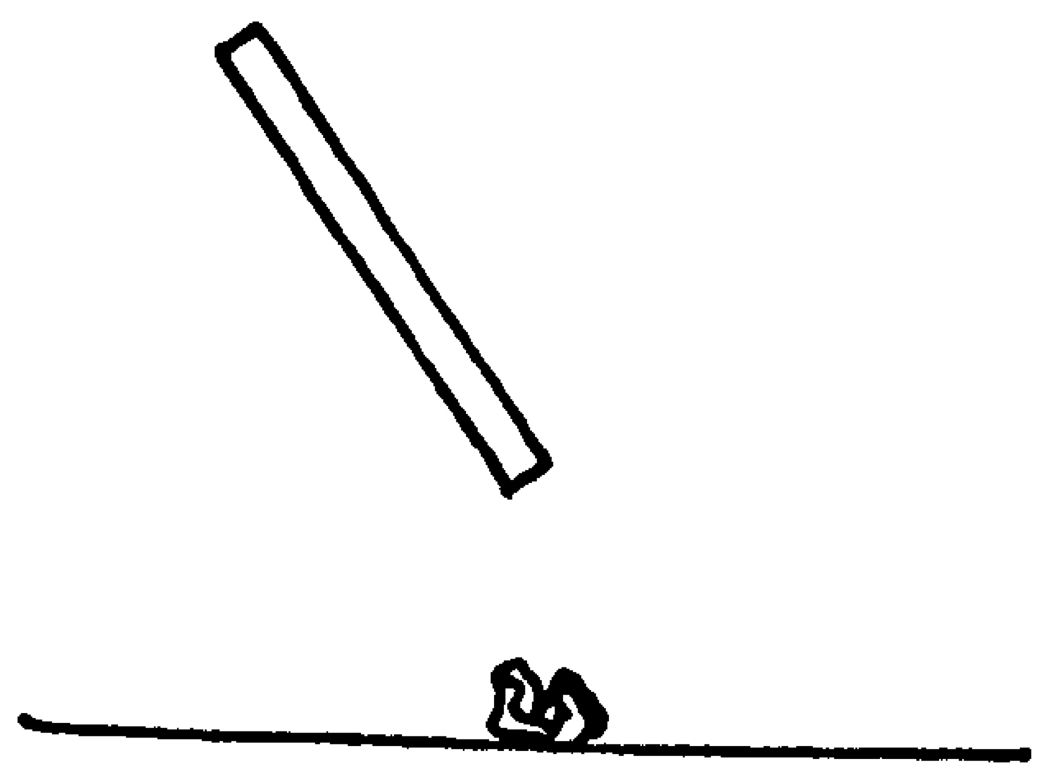
Assignment:

The following diagrams show situations where two forces are involved on an object. In each case state what the forces are and which is the stronger, and why.

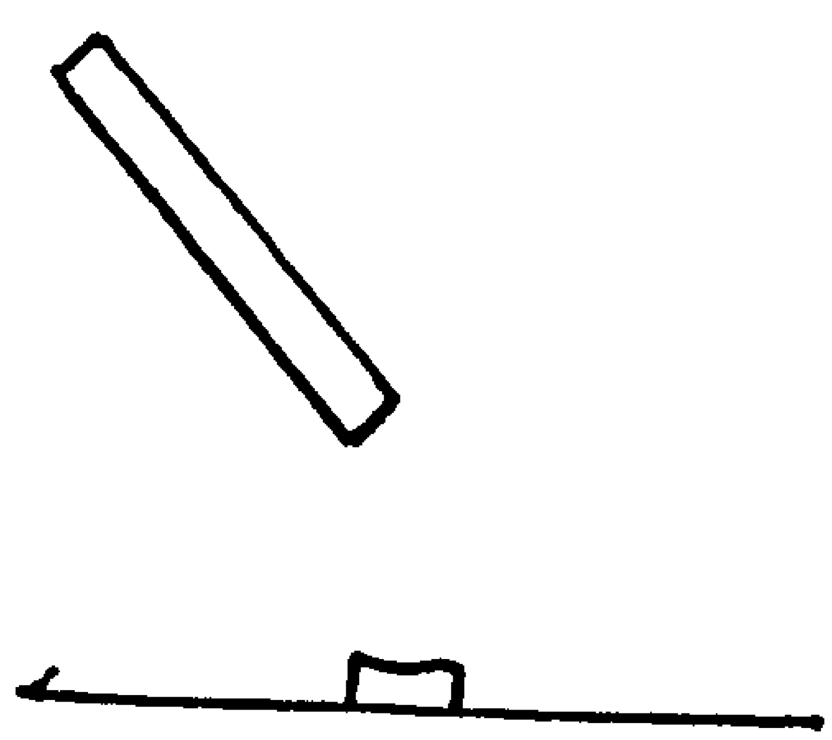
a. A magnet picks up a nail.



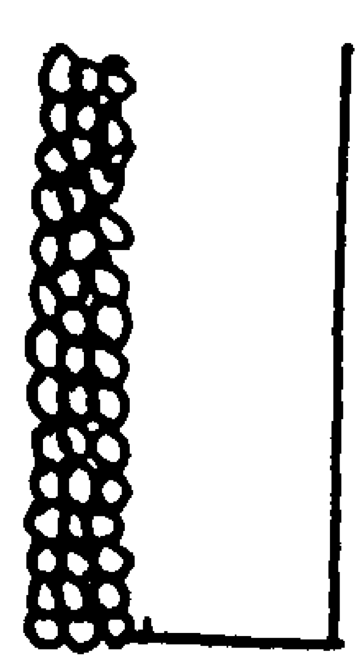
b. A charged glass rod does not pick up a piece of paper.



c. A magnet does not pick up a piece of wood.



d. Atoms on a bar of iron remain attached to each other.



CRIME DETECTION AND HAIR

The following article presents a series of interesting examples of how the identification of hair samples has been used to solve some unusal criminal cases. It is a good example of the use of scientific techniques toward the solution of practical problems.

During the past century, numerous criminal cases have occurred in which the identification of hairs belonging to the mammalian group of animals has played an important part in furnishing strong circumstantial evidence of the guilt of accused persons. In order to verify this contention the reader need but refer to the following British cases:— Reg. v. Teague, (Cornwall Assizes 1851), Reg. v. Harrington (Essex Lent Assizes 1852), Reg. v. Hansen, (Bodmin Lent Assizes), and Reg. v. Steed (Maidstone Summer Assizes 1863). These are representative of the earlier English cases in which the medico-legal examination of hairs and fibres proved of great value in the course of justice. Taylor, states that "the necessity for an acquaintance with the character of hair will be apparent from the case of Reg. v. Teague. In this case it was alleged that the fatal wounds to the head of deceased involving both eyebrows, had been produced by a hammer found on a hedge. There was not any blood upon the hammer, but there were two short stiff white hairs at the smaller end. It was suggested that these might have been goat hairs as the hammer was used for beating out portions of goat skin which were hanging in the same hedge. Two medical witnesses deposed that they were hairs from the human eyebrow and having compared them with deceased's eyebrow, they found they agreed. The hair of the eyebrow was described as conical or pyramidal and the hair on the hammer had this character. It appeared as if it had been bruised or squeezed between two blunt substances, but this appearance might have been equally presented on the theory of defence that it was goat's and not human hair. Assuming the medical evidence to be correct, it pointed to the weapon and not to any act on part of prisoner. The witnesses were severely cross-examined upon the structural differences of the hair of man and animals." Among the more recent Scottish criminal cases which may be cited in this regard are:— Rex v. Gibson, High Court Justiciary, Glasgow, December, 1924, Rex v. Thomson, Sheriff Court, Ayr, (Winter 1924), and Rex v. Handley, High Court Justiciary, Glasgow, October 1926. The first, refers to a case in which a man was accused of cutting a boy's throat. The prisoner was found to be insane and unable to plead. At the enquiry, evidence was led to show that he was affected with an insane impulse to kill cats. It was stated that he had killed twenty. Hairs of this animal were found upon his clothing. The second, concerns a case of theft in which a superficial examination of the clothing belonging to the accused man revealed the presence of several hairs upon its surface. The microscopic appearances of these hairs were identical to those found composing a fur necklet which the accused man was alleged to have stolen. This evidence assumed a very important rôle in bringing the accused to justice. The third case was one of rape and murder in which a hair found upon the trousers of the accused was very similar in all respects to the pubic hair of the victim. With this case, the writer was associated as one of the medico-legal examiners for the Crown.

In passing, allusion should be made to the notable English trial of H. H. Crippen, October 1910, in which the question of hair identity arose.

The study of hair characteristics is also of very great value when an examiner is called upon to investigate cases of cattle and animal maiming. There are in addition many other types of cases in which an intimate knowledge of the appearances of hairs is essential. In a case of animal maiming which was tried at the Reading Assizes in the early summer of 1926, the accused, James May, was sentenced to seven years penal servitude by Mr. Justice Avory. Evidence was led to show that the hairs which were found on his coat were those of short-horns, similar to the herd some of which had been maimed.....

Project:

Investigate the effect of hair products such as laquers, sprays, permanent wave solutions on the elasticity of hair. Providing hair is elastic it can be stretched but will return to its original length. However many chemicals soften it so that it can be stretched but it loses its elasticity and remains permanently damaged. See how these different types of products change the nature of hair.

VI. SOCIETY AND HAIR

In our society considerable emphasis is placed on hair. Besides simply being an adornment, it is also looked on as being reflective of our personalities. Thus many people view long hair as a sign of rebellion, and red hair as an indicator of a quick temper. The fact that our attitudes are influenced by hair is looked at in a light-hearted manner in the first section.

In the second section we examine one aspect of the economic importance of hair, advertising, and you will design an experiment to test one of the many claims made.

Attitudes to Hair

Showing off the hair on the head seems to be the main use to which we put our hair. In his book, The Long and Short of It; Five Thousand Years of Fun and Fury Over Hair, Bill Severn states:

> Hair has been a cause of fury since history began. If one generation accepts long hair, the next insists it must be short; if young rebels wear beards, those who come next revolt against beards; if women sweep their hair high, younger women challenge conformity by combing it down. Always there have been some people who have tried to tell others how to wear their hair. Sometimes with rage, and sometimes with laughter, we have been getting into each other's hair for at least five thousand years.

The statements below were taken from the above mentioned book. Make a guess in the spaces provided as to the possible times and places under which the described events took place.

1. "He wanted to be different from others, so he wore his hair long, but a band of men seized him and cut it off."

2. "Young people have "bad manners." Their hair is "atrocious."

3. "Women who wear wigs are out 'to deceive the men' and should be made to stop such a very wicked thing."

4. "A young man appeared in court wearing a long beard and the judge ordered him from the courtroom to shave it off before he would hear the case."

5. "The Massachusetts legislature has passed a law against long hair."

6. "Students at Harvard have been forbidden to wear long hair."

7. "Long-haired rebels are "savages" who should be barred from respectable home."

8. "The way young men and women wear their hair, it's hard to tell one sex from the other."

Do you think that the attitudes expressed in some of these statements are well founded?

Advertising and Hair

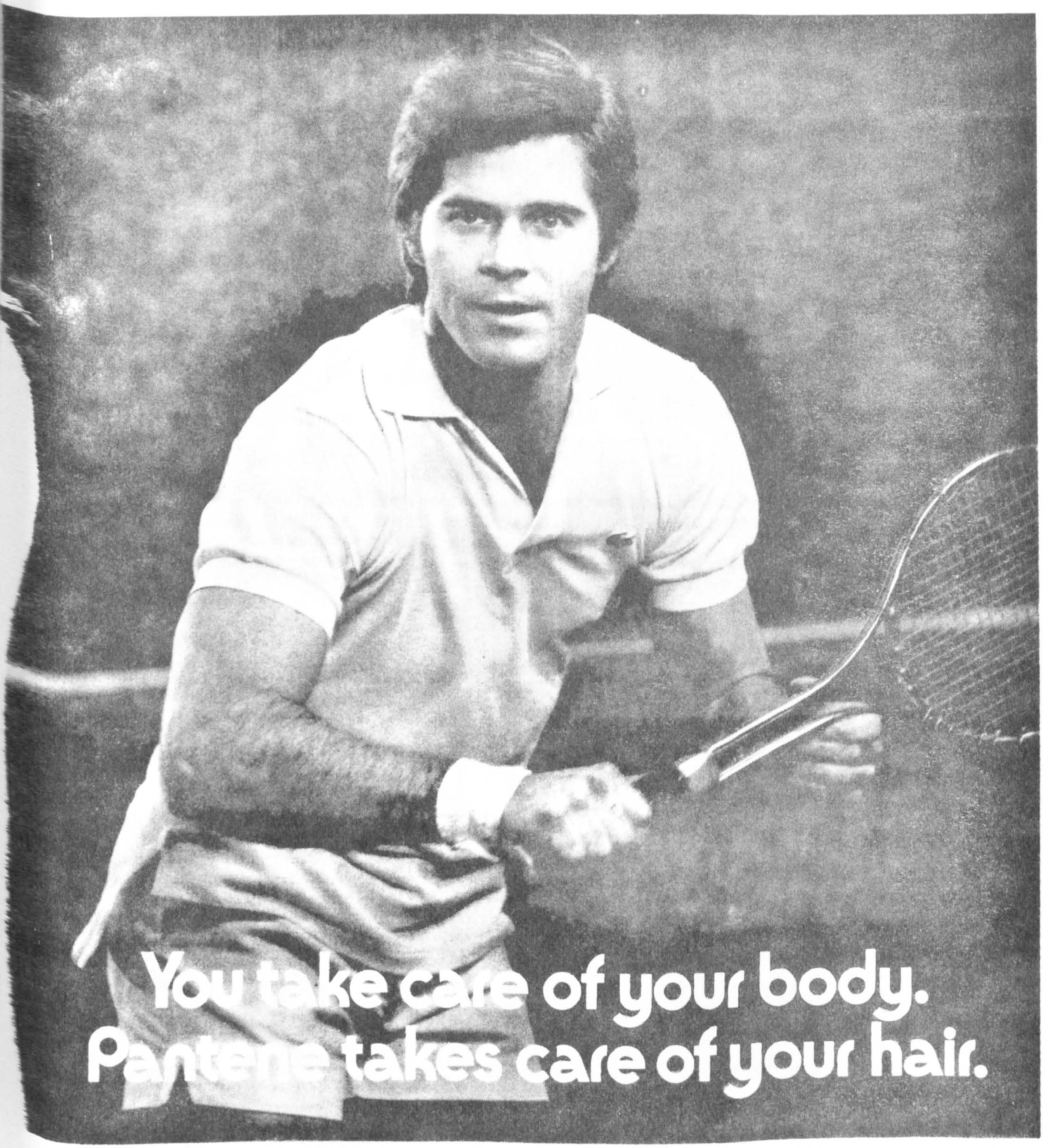
There are literally hundreds of products on the market that deal in one form or another with human hair. These range from hair removers (razor blades, electric shavers, shaving creams) and hair conditioners (shampoos, hair sprays, brushes) to hair modifiers (dyes, hair setters, hair dryers) and hair itself (wigs, artificial mustaches and beards).

In addition there are a variety of hair services provided by barbers, hair dressers, hair transplant specialists and dermatologists.

Hundreds of millions of dollars is spent each year on radio, television, newspaper and magazine advertisements intended to convince you that a particular product is smoother, sharper, faster, safer, cleaner, healthier or longer lasting than its competitors. In North America "hair" is clearly big business!

The average person spends hundreds of hours and hundreds of dollars each year taking care of his hair. All of this time and money is spent on a dead commodity whose only real function in humans is to serve as a means of sexual attraction and to keep nasal mucus from running onto the upper lip.

A few of the common advertising claims made for hair products are shown on the following pages.



The Pantene physical fitness program is designed to put the look of new body and health into hair. And our exclusive Swiss Conditioning* agent helps make it work.

Here's the program. First, Pantene Shampoo (one creamy lather does it). Then, Pantene Conditioner helps undo the drying damage caused by sun and wind.

For control, use Pantene Hair Groom. Keeps unruly hair in place, and looking natural. And for bright-looking hair between shampoos, try Pantene Hair Lotion. Start the program. And stop worrying.

The Physical Fitness Program for Hair: Pantene®

To know you're the best you can be*

Hair color—the best it can be!

Miss Clairol*

Does she...or doesn't she?*

*TM © 1972 CLAIROL CANADA, Div. of Bristol-Myers Canada Ltd., Auth. User Knowlton, Brom


Close shaves, but...
Change blades. Change accuracy. Improper clamping can upset blade angle and exposure, misalign blades.
Bulky head. Hard to use in tight spots.
Complex clamping mechanism. It can get out of line with wear, and lead to nicks and cuts.
Closer shaves. Better protection from nicks and cuts.
No moving parts. You don't just change blades, you change the whole shaving head.
Permanent precision. Blade angle is scientifically fixed, edge exposure precision set. You get closer shaves with better protection from nicks and cuts.
Compact shaving head. Much thinner, narrower. Fits the topography of your face better.
Up till now, men liked their double-edge razors for close shaves. But now there is something better... the Wilkinson BONDED Razor. It not only shaves closer, but also gives you better protection from nicks and cuts.
The Wilkinson BONDED is so advanced that when tested against the most popular double-edge razor, with hundreds of men, it won in every category of shaving performance. The Wilkinson BONDED was superior for less irritation, better first shaves, longer blade life, and closer shaves with fewer nicks and cuts.
Clearly, the Wilkinson BONDED Razor is a major advance over the kind of razor most men shave with.
THE WILKINSON® BONDED™ RAZOR.
A BETTER WAY TO SHAVE
Bonded Razor
Bonded Blades
© 1973, Wilkinson Sword Inc.
Trademarks are the property of Wilkinson Sword, Limited, London, England.


Save
your
skin.
Gillette Techmatic.
It's tough on your beard.
Not on your face.

There were more cuts on my face than on my records...

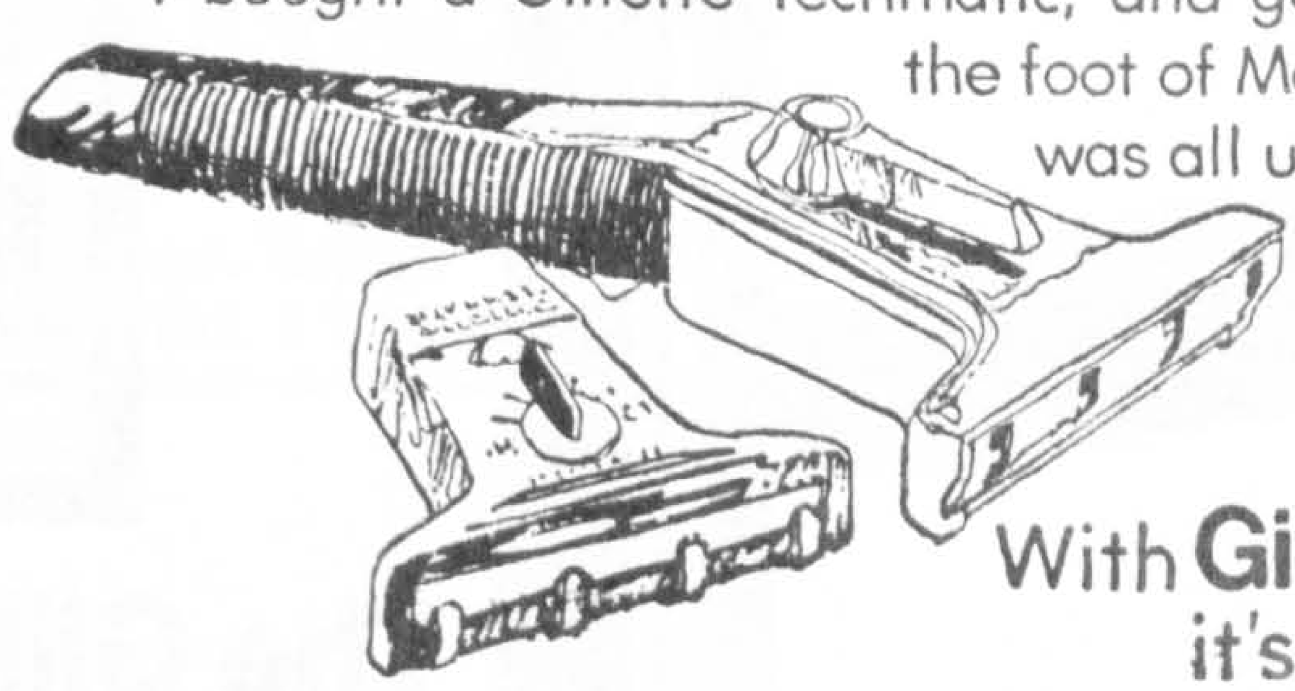
"Good-bye NICK"

My name is Tim Wheeler. I started singing for free beer, then the General discovered me and I was asked to sing at a concert at the foot of Mount Rushmore.

My songs talked of the quiet, peaceful life. But people were noticing the bandages on my face. I always nicked and cut myself when I shaved. People called me "Nick." There were more cuts on my face than on my records. The General called me out on the veranda. "Nick," he said. "They cancelled your appearance at Rushmore. I can't sell a peaceful singer who looks like his appearance at Madison Square Garden was a ten-rounder, instead of a concert. Good-Bye Nick."

On the bus for Atlanta I told a guy my story. From his cardboard satchel he took out a razor. "This is a Gillette Techmatic® razor," he said. "Instead of blades with sharp corners that can cut and nick your face, it has a continuous razor band all safely enclosed in a cartridge. And it's adjustable to your skin and beard, for a smooth, safe shave."

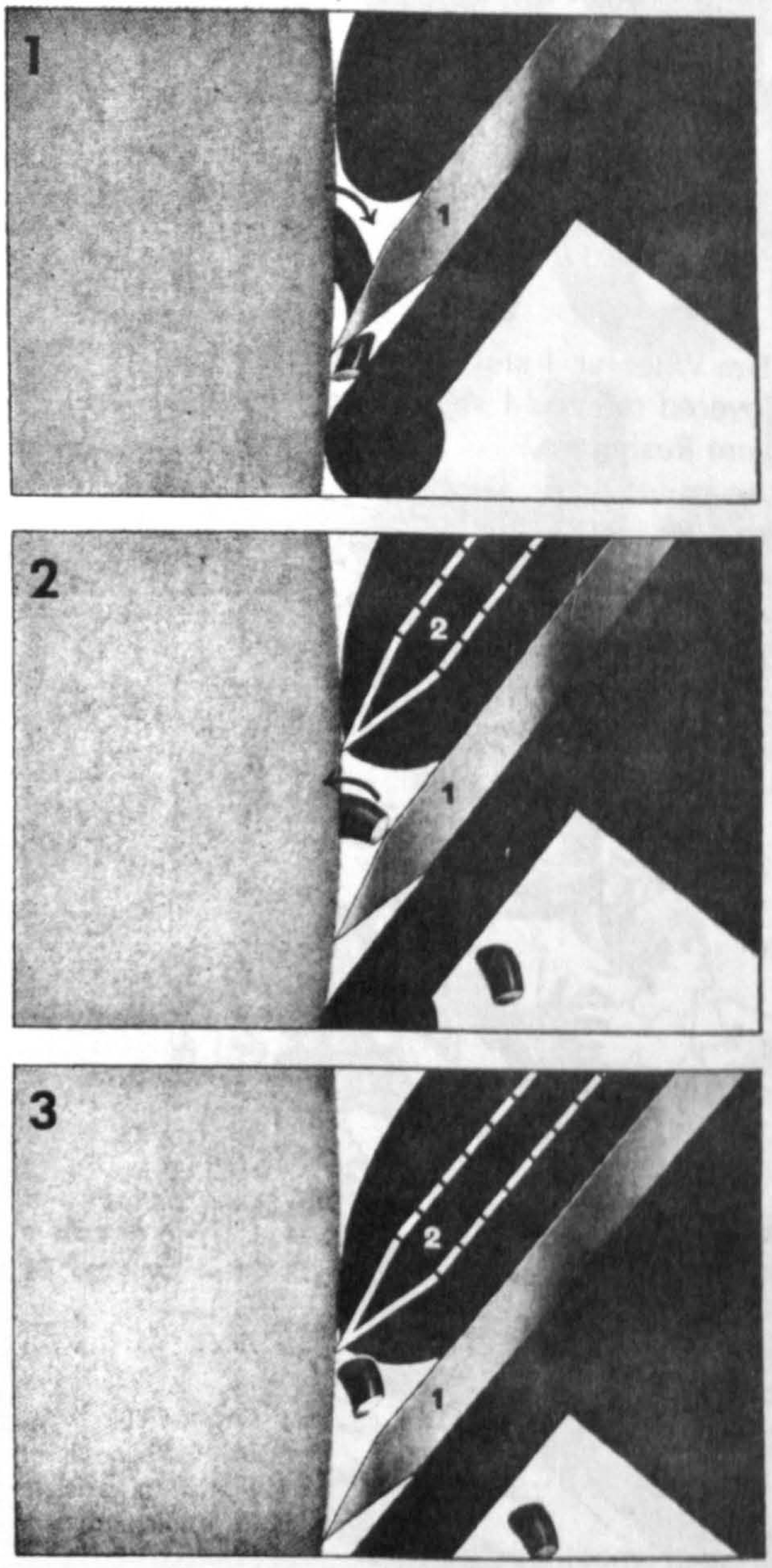
I bought a Gillette Techmatic, and got great shaves. I sang at the foot of Mount Rushmore, and it was all up from there.



With **Gillette TECHMATIC**
it's good-bye Nick.

5.

Here's why your razor could use a second blade.

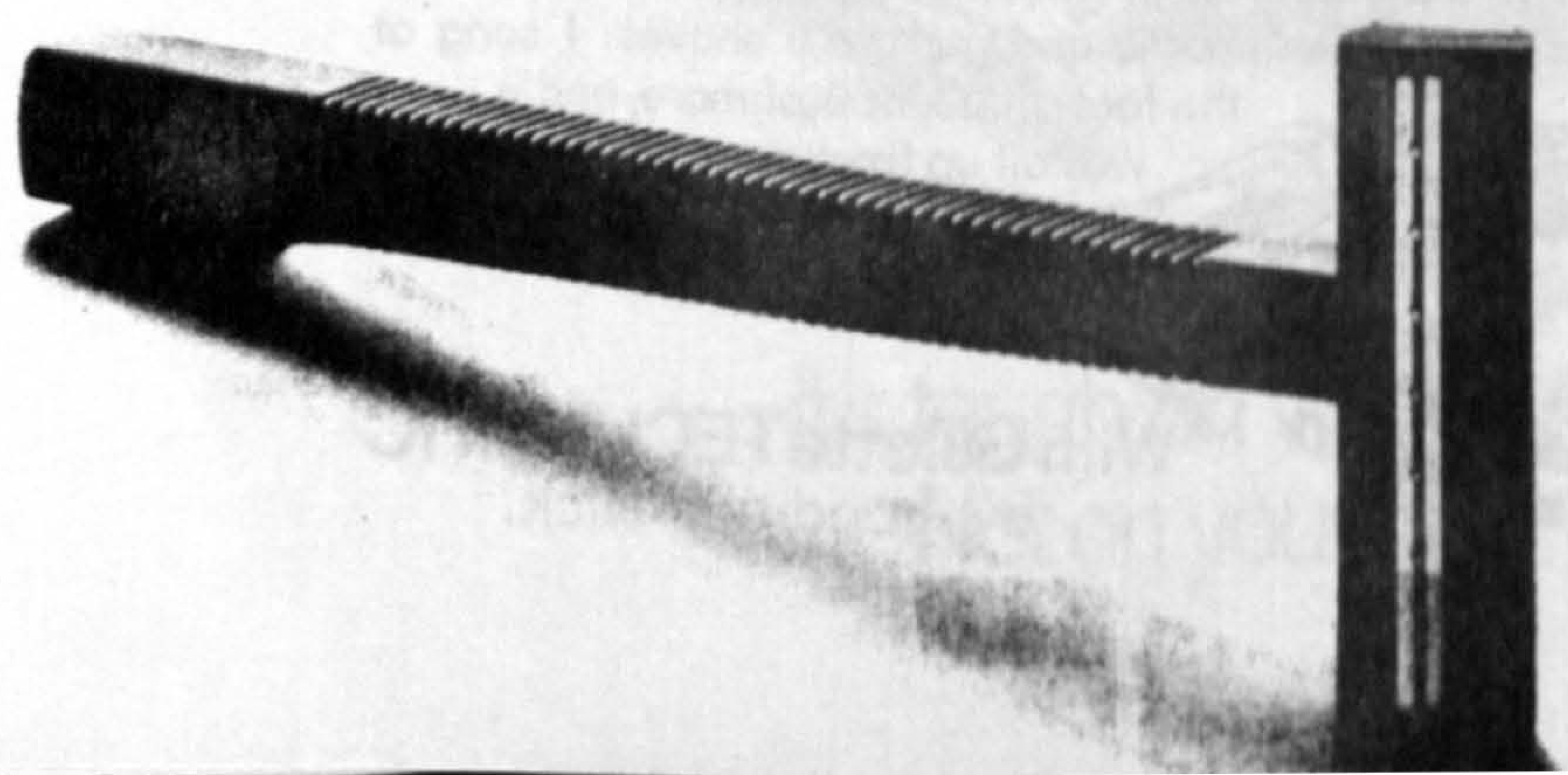


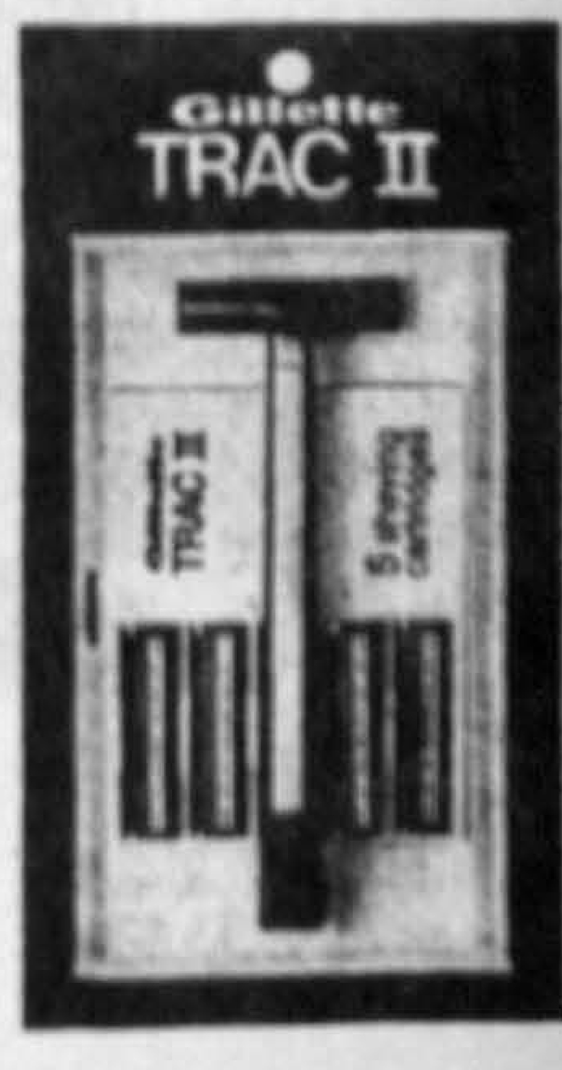
(1) When you shave with your one blade razor, the blade actually stretches the whisker out from the skin for a moment. **(2)** But after your razor shaves it, the whisker snaps right back. Now, if you had a second blade in your razor, right behind the 1st one... **(3)** you could shave that whisker again, before it had a chance to snap all the way back. This would mean you'd get a closer shave.

What's more, if you had 2 blades shaving so close, you could recess them for extra safety. So if your razor had 2 blades, you could outshave any one blade razor in the world.

Of course, if your one blade razor did have 2 blades, it wouldn't be your one blade razor anymore.

It would be our 2 bladed one.





The Gillette TRAC II Two Bladed Razor

It's one blade better.

NOW HAPPY! I had ugly superfluous hair . . . was unloved . . . discouraged. Tried many things . . . even razors. Nothing was satisfactory. Then I developed a simple, painless, inexpensive, non-electric method. It has helped thousands win beauty, love, happiness. My **FREE** book, "What I Did About Superfluous Hair" explains method. Mailed in plain envelope. Also Trial Offer. **Write Mme. Annette Lanzette,** P.O. Box 610, Dept. C 308, Adelaide St. P.O., Toronto 210, Ont.

THINNING HAIR

AFTER HAIR-THIC　　AFTER HAIR-THIC

BEFORE HAIR-THIC　　BEFORE HAIR-THIC

Hair looking Thin? A remarkable formulation **HAIR-THIC** could solve the appearance of your thinning hair. This is a suspended emulsion of highly specialized ingredients, when released appears to multiply the "body" of every hair. **Instant result**—richer and fuller looking head of hair.

VIRILITY-APPEARANCE RESTORED TO THINNING HAIR. Instantly **HAIR-THIC** restores youthful virility-appearance to hair. You regain self-confidence that goes with a thick head of hair; both professionally and socially. Used daily by thousands.

FROM A FEW OF THE MANY SATISFIED CUSTOMERS

"My hair always looked thin. Now it looks thicker. I look younger thanks to HAIR-THIC."—**C. S., Portland Ore.** • "My hair has improved so much. It's a wonderful product."—**B. K., Reynoldsburg, Ohio** • "It's a great help to fine hair."—**Miss H. C., Santa Cruz, Calif.** • "Had good luck with your product for making hair look thicker."—**D. C., Oklahoma City, Okla.** • "HAIR-THIC it's just wonderful. It's doing wonders for me."—**K. C., Pittsburgh, Pa.**

YOURS FREE! with order of **HAIR-THIC.** "GUIDE TO HEALTHY HAIR," by a Dermatologist M.D., considered an authority in his field. Illustrated, for men and women. Covers: • How to recognize and what to do about hair and scalp disorders that can lead to baldness. • Use of proper diet for better hair and scalp health. • Care of the hair and scalp. • Proper use of hair cosmetics and cosmetic procedure.

YOURS FREE!

SEND NO MONEY! NO RISK 10-DAY TRIAL! Send name and address. Pay postman $1.98 plus postage for 60 day supply of **HAIR-THIC,** Plus **FREE** manual "GUIDE TO HEALTHY HAIR." Or send $1.98 with order, we pay postage. (2 **HAIR-THIC,** $3.50; 3 for $5.00.) **MONEY BACK GUARANTEE,** return unused portion, if not satisfied after 10 day trial for full refund. Keep **FREE MANUAL.**

Copyright 1970 The Liftee Co

THE LIFTEE CO., Dept. THB607
Box 608, Church Street, New York, N.Y. 10008

LONGER, THICKER HAIR INSTANTLY!

ONLY $2.98

Now, you too, can have Lustrously Long, Luxuriously Thick, easy to manage hair. Amazing HAIR BEAUTY formula, developed through scientific research can actually make hair look THICKER and LONGER, so that you look years younger. Ends breaking, splitting hair. It's simple . . . fast . . . **and it works. Contains no grease or alcohol, looks natural. Send only $2.98 (3 month supply).** No C.O.D.'s. **AMERICAN IMAGE CORP., Dept. K-482-M**
276 Park Avenue South, New York, N. Y. 10010

UNWANTED HAIR REMOVED FOREVER

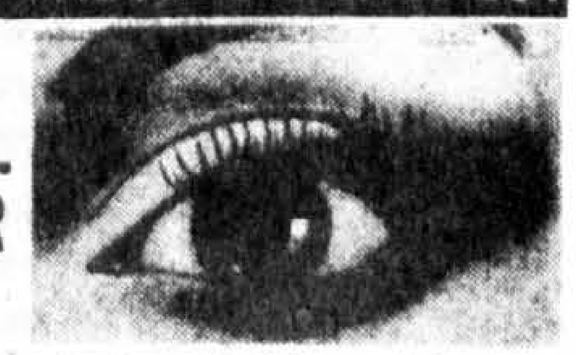
with *Lemos Permagon*
only 7.95

No Scraping. No Tweezing. No Chemicals. A few minutes and unwanted hair is out—gone forever. No need to suffer the embarassment of unfeminine unsightly hair. Now in the privacy of your own room you can be rid of unwanted hair from most any part of your body once and for all. This home electrolysis unit, the size of a ball point pen, has been used by thousands. It is simple, safe and effective. It takes only a few moments. And once it's out, it's gone forever — guaranteed never to grow back again! Results and satisfaction are guaranteed or your money will be refunded without question. Just send $7.95 plus 25¢ for postage and handling and we will **ship complete, everything you need.**

The Lemos Company Dept. 16440
1044 Northern Blvd., Roslyn, N.Y. 11576

SAY GOODBYE TO FALSE EYELASHES!

Your LASHES LOOK LOVELIER.. THICKER..LONGER OVERNIGHT!



For eyes so intriguing . . . that you're bound to capture the interest of a secret somebody . . . use LONG LASH the Instant Eyelash Oil. Just apply . . . go to sleep . . . wake-up . . . and you have glamorous looking lashes. Completely hypoallergenic. Send only **$2.98 for 6 months supply.** Sorry, No C.O.D.'s.
AMERICAN IMAGE CORP., Dept. T-482-M
276 Park Avenue South, New York, N.Y. 10010

PEANUT OIL POMADE

with Protein & Turtle Oil

REVOLUTIONARY DISCOVERY BY A GREAT SCIENTIST—For a healthy scalp, to combat dandruff and itching scalp, to help grow long, abundant hair which is so fashionable today.

For Dry or Oily Scalps

8 oz. $3.50　4 oz. $2.00 + 25¢ postage

FOR MEN, WOMEN, CHILDREN

No C.O.D. Send Check or Money Order

MARCHADO LABORATORIES, Dept. K-17
Box 435, Corona, N.Y. 11368

6.

An Important Message

To Every Man and Woman

In America

Losing His or Her Hair

If you are troubled by thinning hair, dandruff, itchy scalp, if you fear approaching baldness, read the rest of this statement carefully. It may mean the difference to you between saving your hair and losing the rest of it to eventual baldness.

Baldness is simply a matter of subtraction. When the number of new hairs fail to equal the number of falling hair, you end up minus your head of hair (bald). Why not avoid baldness by preventing unnecessary loss of hair? Why not turn the tide of battle on your head by eliminating needless causes of hair loss and give Nature a chance to grow more hair for you? Many of the country's dermatologists and other foremost hair and scalp specialists believe that seborrhea, a common scalp disorder, causes hair loss. What is seborrhea? It is a bacterial infection of the scalp that can eventually cause permanent damage to the hair follicles. Its visible evidence is "thinning" hair. Its end result is baldness. Its symptoms are dry, itchy scalp, dandruff, oily hair, head scales, and progressive hair loss.

So, if you are beginning to notice that your forehead is getting larger, beginning to notice that there is too much hair on your comb, beginning to be worried about the dryness of your hair, the itchyness of your scalp, the ugly dandruff — these are Nature's Red Flags warning you of impending baldness. Even if you have been losing your hair for some time, don't let seborrhea rob you of the rest of your hair.

Note To Doctors

Doctors, clinics and hospitals interested in scalp disorders can obtain professional samples and literature on written request.

Male pattern baldness is the cause of the great majority of cases of baldness and excessive hair loss. In such cases neither the Comate treatment nor any other treatment is effective.

"I used to comb out a handful of hair at a time. Now I only get 4-6 on my comb. The terrible itching has stopped."
—L. H. M., Los Angeles, Cal.

"My hair has improved. It used to fall out by handfuls. Comate stopped it from falling out." —D. M. H., Oklahoma City, Okla.

"Comate is successful in every way you mention. Used it only a few days and can see the big change in my scalp and hair."
—C. E. H., N. Richland, Wash.

"My hair was thin at the temples, and all over. Now it looks so much thicker, I can tell it."
—Miss C.T., San Angelo, Tex.

"Now my hair looks quite thick."
—F. J. K., Chicago, Ill.

"My hair had been coming out and breaking off for about 21 years and Comate has improved it so much."
—Mrs. J. E., Lisbon, Ga.

"My hair has quit falling out and getting thin."
—D. W. G., c/o FPO., N. Y.

"My husband has tried many treatments and spent a great deal of money on his scalp. Nothing helped until he started using your formula."
—Mrs. R., Lee, Piqua, Ohio

"I've used a good many different 'tonics.' But until I tried Comate, I had no results. Now I'm rid of dandruff, and itchy scalp. My hair looks thicker."
—G. E., Alberta, Canada

"Used it twice and my hair has already stopped falling."
—R. H., Corona, Cal.

"No trouble with dandruff since I started using it."
—L. W. W., Galveston, Tex.

"It really has improved my hair in one week, and I know what the result will be in three more. I am so happy over it, I had to write!"
—Mrs. H. J., McComb, Miss.

U
C

HOW COMATE WORKS ON YOUR SCALP

The development of an amazing new hair and scalp medicine called Comate is specifically designed to control seborrhea and stop the hair loss it causes. It offers the opportunity to thousands of men and women losing their hair to bacterial infection to reverse the battle they are now losing on their scalps. By stopping this impediment to normal hair growth, new hairs can grow as Nature intended.

This is how Comate works: (1) It combines in a single scale treatment the essential corrective factors for normal hair growth. By its rubifacient action it stimulates blood circulation to the scalp, thereby supplying more nutrition to still-alive hair follicles. (2) As a highly effective antiseptic, Comate kills on contact the seborrhea-causing scalp bacteria believed to be a cause of baldness. (3) By its keratolitic action it dissolves ugly dandruff. By tending to normalize the lubrication of the hair shaft it corrects excessively dry and oily hair. It eliminates head scales and scalp itch.

In short, Comate offers you in a single treatment the best that modern medicine has developed for the preservation of your hair. There is no excuse today except ignorance for any man or woman to neglect seborrhea and pay the penalty of hair loss.

COMATE IS UNCONDITIONALLY GUARANTEED

To you we offer this UNCONDITIONAL GUARANTEE. Treat your scalp to Comate in your own home, following the simple directions. See for yourself in your own mirror how after a few treatments, Comate makes your hair look thicker and alive. How Comate ends your dandruff, stops your scalp itch. How Comate gives your hair a chance to grow. Most men and women report results after the first treatment, some take longer. But we say this to you. If, for any reason, you are not completely satisfied with the improvement in your own case — AT ANY TIME — return the unused portion for a prompt refund. No questions asked.

But don't delay. For the sake of your hair, order Comate today. Nothing — not even Comate — can grow hair from dead follicles. Fill out the coupon now, and take the first step toward a good head of hair again.

RUSH THIS NO RISK COUPON TODAY

COMATE CORPORATION Dept. 16440
21 West 44th Street, New York, N.Y. 10036

Please send at once the complete COMATE hair and scalp treatment (60 day's supply) in plain wrapper. I must be completely satisfied with the results, or you GUARANTEE prompt and full refund on return of unused portion.

☐ Enclosed find $10 (check, cash, money order). Send postpaid.

☐ Send C.O.D. Enclosed is $1 deposit. I will pay postman $9 plus about $1.50 in postal charges on delivery. Save the $1.50 by enclosing $10. Canada, Foreign, APO, FPO, add $1 - No C.O.D.

Name____________________

Address____________________

City__________ State________ Zip________

"Permanently Set" STRETCH WIGS

Any Style only 5^{95} worth much more

- Ready-to-wear styles
- Never need setting

Stretch Wig Style S132

- Choice of 17 attractive colors or custom matched to your own hair
- Permanently set—wash and wear—the setting bounces back
- Made of miracle modacrylic fiber—has the luster, rich body and bounce of human hair—behaves better than real hair
- Looks and feels like real hair—you'll mistake it for your own
- No costly settings at the beauty parlor
- Light, airy, special design net base stretches for comfortable natural looking fit
- Packs in your purse—crush resistant

Stretch Wig Style S136

MAKE THIS SPLIT-SECOND CHANGE TO A NEW PERSONALITY: A variety of ready-to-wear styles that add luxurious fullness to limp or thin hair, waves to straight hair, length to short hair. Be bewitching, daring, winsome, demure! If not completely satisfied with this tremendous value in stretch wigs, you can return your order for full refund within 10 days. Mail coupon now while this offer lasts.

Stretch Wig Style S165

Stretch Wig Style S124

SEND NO MONEY! FREE 10 DAY TRIAL COUPON!

FRANKLIN FASHIONS CORP., Dept. S919
378 S. Franklin St., Hempstead, N.Y. 11550

Rush my "Permanently Set" Stretch Wig checked. I will pay postman on delivery $5.95 plus postage. I must be absolutely satisfied or I can return my order within 10 days trial and my money will be refunded.

Check Box of Style Number Desired
☐ S136 ☐ S124 ☐ S132 ☐ S165

Check Box of Color Desired (or Send a sample of Your Hair for Expert Matching)

☐ Black
☐ Off Black
☐ Light Brown
☐ Medium Brown
☐ Dark Brown
☐ Light Blonde
☐ Medium Blonde
☐ Dark Blonde
☐ Ash Blonde
☐ Platinum
☐ Light Auburn
☐ Medium Auburn
☐ Dark Auburn
☐ Light Frosted
☐ Dark Frosted
☐ Mixed Black & Grey
☐ Mixed Brown & Grey

Name ______________________

Address ______________________

City ______________ State ________ Zip ______

☐ *Check here if you wish to save postage and C.O.D. fees by enclosing only $5.95 with order. Same money back guarantee. N.Y. State residents add sales tax.*

Imagine yourself ten years younger.

"Mirror, mirror on the wall make gray hair vanish once and for all."

If some magic mirror could make you look any younger, odds are one of the first changes would be your gray hair.

It's no secret that gray hair is associated with getting old.

But it's quite a secret that millions of men are using "RD" Hairdressing to look younger.

"RD" changes gray hair back to a youthful natural colour. Not overnight, but gradually over a period of about fourteen days. So no one's going to know why you seem to be looking so much younger except you. (You might even start getting compliments on how smart your clothes are but that's just because they seem to look better without the gray.)

"RD" isn't a messy dye that's going to streak or rub off or wash out. "RD" is a fine hairdressing that grooms and conditions your hair at the same time as it subtly removes the gray.

You can darken all your gray or as much as you like, it's as simple as combing your hair.

After about two weeks using "RD" daily, just use it only as often as needed.

The secret of youth is so well kept with "RD" that you would never suspect over two million tubes have already been sold and it's the leading men's hair colour preparation in Canada.

Stop imagining yourself ten years younger right now. Start looking ten years younger with "RD".

Then go out and act your new age.

Results guaranteed or money refunded.

Available at all drug counters. New economy size bottle $5.00 or new tube $2.50. Medco Products Co., 1801 Eglinton Ave.W., Toronto 345, Ontario.

Sometimes a single company will produce products that sell for the same price but which compete with each other. For example Gillette makes a double edge razor, a single edge razor and a two bladed razor all of which are designed to "last longer, shave closer, and feel more comfortable." In one advertisement Gillette makes the following statement about their TECHMATIC razor: "instead of blades with sharp corners that can cut and nick your face, it has a continuous razor band all safely enclosed in a cartridge." Yet Gillette also makes a double edge blade with sharp corners! Also, Gillette makes a TRAC II two bladed razor which is supposed to shave you 40% closer than any single blade. But Gillette makes two single edge blades.

How can you a consumer, evaluate claims made for hair products? Typically a radio or television advertisement presents a "test" or "experiment" intended to show that a product is better in some specific way than its competitors. How valid are these tests? Are the results biased in any way? Are all important results reported? You as the consumer must be constantly aware of advertisements which demonstrate faulty logic, biased tests, and misleading statements. Look over the advertisements presented on the previous pages and as a class discuss in what ways these statements may be misleading, inaccurate, subject to faulty logic and so on.

Now you will have an opportunity as a class to actually carry out an experiment to test the claims made for one particular hair commercial.

Below is a verbatim transcript of a television commercial for the men's hair spray product WINDBREAK. In the commercial two men are sitting together on a balcony by a lake. One man has used WINDBREAK on his hair and the other man has apparently not used anything. The difference between the way their hair remains in place is dramatic.

Man 1: This is a great idea, buddy, lunch by the lake.

Man 2: Yea, but I should have worn a hat. How do you keep your hair from drying out?

Man 1: WINDBREAK. Makes my hair practically windproof.

Man 2: WINDBREAK? I've seen that. WINDBREAK Hair Control, right?

Man 1: Right! When the wind blows, it holds.

Lady: Say, is that WINDBREAK on your hair?

Man 1: Yes.

Lady: You know, you can't tell.

Announcer: WINDBREAK Hair Control. When the wind blows, it holds.

It is clear enough that WINDBREAK holds hair in place better than no hair spray at all. But how does WINDBREAK compare with other hair spray products? This question is neatly avoided in the commercial, but is of great importance if you are trying to decide which hair spray product to buy.

The class kit for this module contains four men's hair spray products, one of which is WINDBREAK. Discuss with the rest of the members of the class how you would design and carry out a test of the claim that "WINDBREAK holds hair better than any other leading men's hair spray".

Outline your methods in the space below. Carry out the experiment. Does it support the advertising claim?

Printed by

Memorial University of Newfoundland
St. John's, Newfoundland, Canada

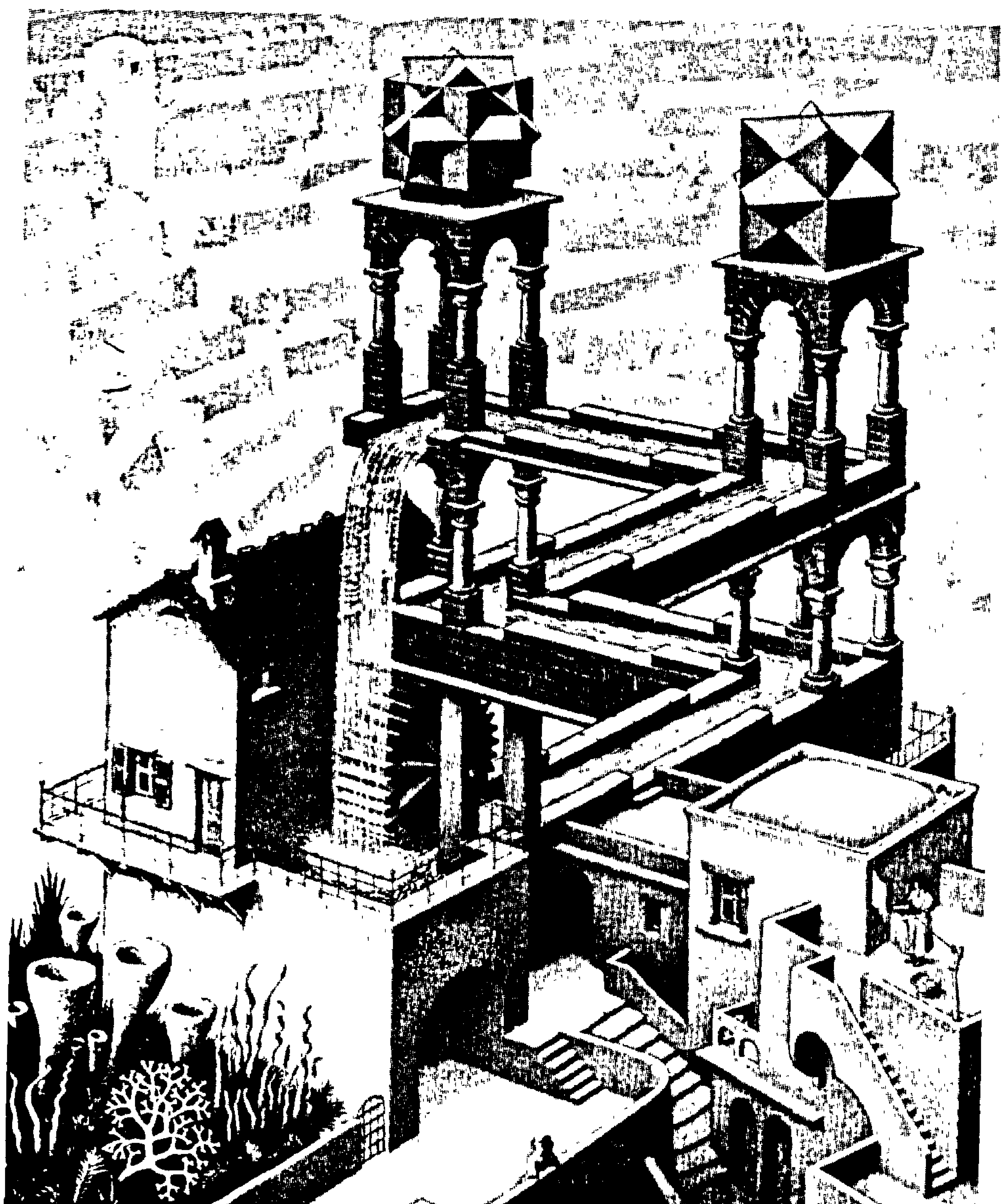
INTEGRATED SCIENCE FOR NEWFOUNDLAND

MODULE II – VISION

SCHOOL: ______________________________

NAME: ______________________________

VISION



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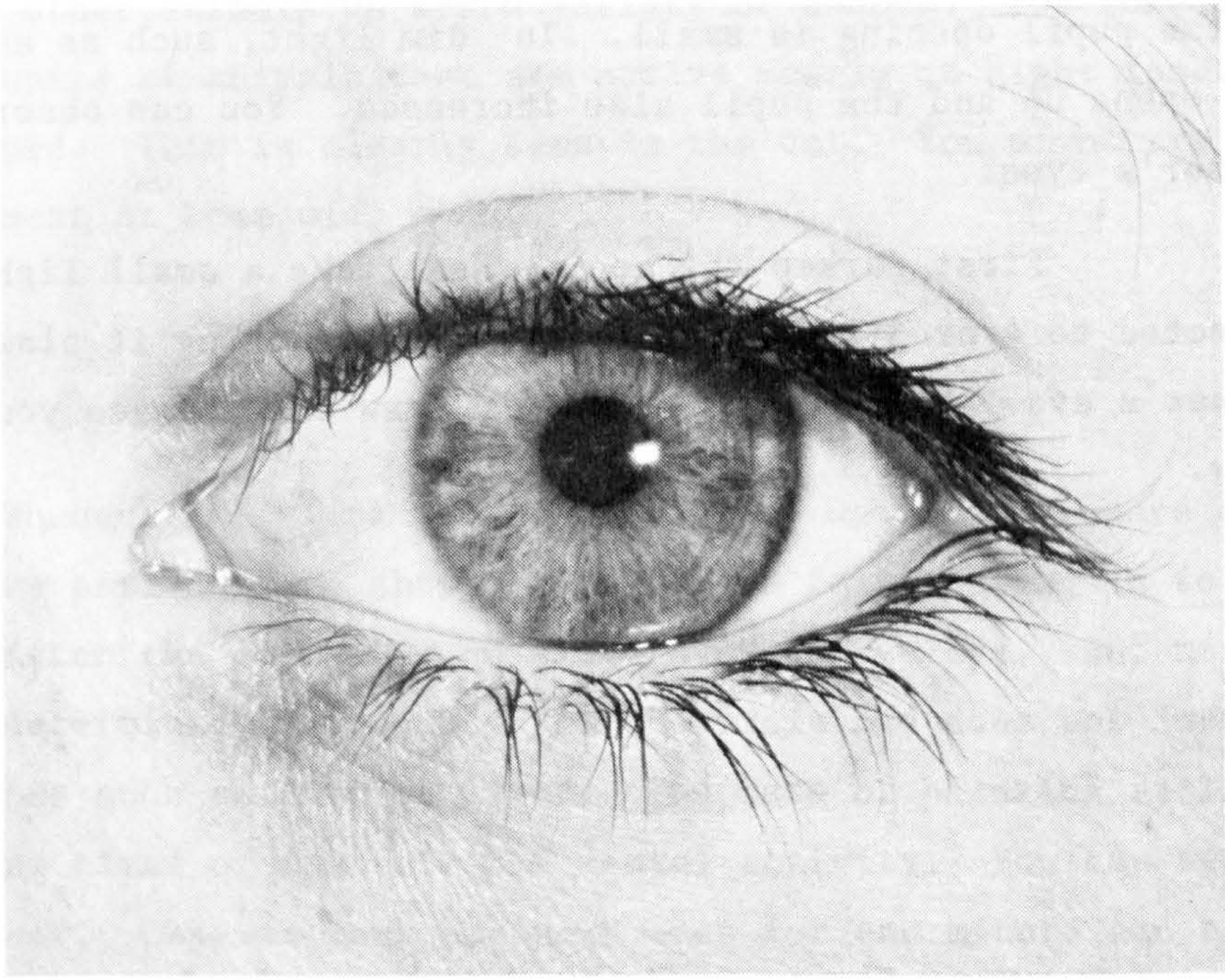
I. INTRODUCTION

We often take for granted that we can see, and yet if we stop and think for a second, there are many questions underlying this wonderful ability. In this module vision you will investigate some of the major ideas of science this topic suggests. Your teacher will show you some slides which should suggest some questions to you. Look at the slides and record any questions that occur to you in the space below. At the end of the module check back and see if you can answer them.

The reprint below "Joe s Eye" contains background background reading for several sections in this module, read it through carefully now, and refer to it later as you reach the appropriate sections.

II. OUR EYES



In this section we are going to find out something about the structure of the eye, and also make some simple observations on the behaviour of the eye. You will also make a disection of a sheep eye. The first part of this section involves some simple observations that will require you to work in pairs.

Observations of your Eyes

Look at your partner's eye and in the space below draw what you see. How many different parts can you observe?

The colored portion of the eye is called the iris. The dark hole in the center of the iris is called the pupil and it is through this hole that light passes into the interior of the eye. The size of the pupil opening is controlled by the iris. In bright light the iris closes down and the pupil opening is small. In dim light, such as a dark room, the iris opens up and the pupil size increases. You can observe this in your partner's eyes.

First darken the room. Next take a small light bulb which is connected to 4 or 5 flashlight batteries and bring it slowly closer to your partner's eye. What do you observe? Draw the changes you see in the space below.

Although the pupil in the human eye is circular, this is a bit unusual. In other animals we see a variety of shapes. For some unknown reason the pupils of animals that are active mostly at night (nocturnal) are slit-shaped. This is clearly seen in the cat. You might try the above experiment at home with a cat.

Blinking

Whenever we blink we are blind, but we are not aware of it because the time period is so short. One reason for blinking is to use the eyelid to moisten the cornea or outside layer of the eye. But normal blinking is determined by signals from the brain and does not depend on outside factors such as dirt or light. The rate of blinking falls below average during times of concentrated mental activity. You can test this in your partner. Observe your partner's eyes for one minute and note the number of times he blinks. This will be considered his normal blink rate. Now give your partner an arithmetic problem to do in his head, such as 37 x 25. Watch his eyes as he works out the problem and record the number of blinks during the time it takes him to get the answer. Convert this to number of blinks per minute and compare your results with his normal blinking rate. Use the space below for your calculations.

Blind Spot

At the back of the eye is the retina, the layer where the light sensitive rods and cones are located. At the point (about the size of a pin head) where the optic nerve joins the retina there are no rods and cones and therefore no response to light. This is called the Blind Spot. To "see" your blind spot, look at the next page, and keeping your left eye closed hold the book about 12 inches from your face. Look steadily at the cross and move the book slowly toward the eye until the circle disappears. At this point, the rays of light from the circle are falling on the area where the nerve enters the back of the eye. This is your blind spot.

BLIND SPOT EXPERIMENT

Assignment:

If you look at people while they are sleeping you may notice that for a period of time their eyes may be open. Do they see anything? This should be an interesting question to answer at home and should give us some idea of the role of the brain in vision. While a member of your family (or perhaps a dog or cat) is sleeping gently open their eyes. What do you notice? Later when they wake up ask them if they recall anything unusual. Report your observations in the space below.

Eye Movement

We can follow a moving object by moving our eyes in their sockets, by moving our head, or by moving both. As we will see later, what we move will have an effect on how we see. In this activity we want to obtain some idea of the range of eye movements that are possible as well as some indication of how wide is our field of vision. Look straight ahead at a fixed object and have your partner move a pencil or pen to the right, left, up and down. Using a protractor determine the angles (up, down, right and left) at which the pencil is no longer visible. Record these below. Does the angle depend on whether or not the pencil is moving.

Now while keeping your head facing straight ahead, repeat the above experiment while moving your eyeballs in their sockets. How do your results compare with the first experiment?

Disection of a Sheep's Eye

In order to give you some understanding of the structure of the eye we have arranged to have you dissect a sheep's eye. As you will discover later there are many similarities between the eyes of a sheep and those of a person.

You will be given one eye between two of you. Before you start to cut it up, look at the eye carefully, and identify the optic nerve and the muscles that attach the eye into the socket. These muscles are also used to move the eye around, so that you (or the sheep) can look in several directions without moving your head. Count the muscles, and try to tell which muscle is used for movement in each direction. Draw the eye from two or three directions, showing the positions of the structures described above, and any others that you can see. Do not put labels on the diagrams yet, but leave room for them as you will be adding them later.

Now you can start to dissect the eye. You should be careful of the instruments that you are given - remember that razor blades are designed to cut flesh - your's as well as the sheep's!

There are several ways to dissect an eye, each of which will show different parts of the internal structure. It really does not matter very much which you use, but try and cut carefully, and cut one structure or layer at a time, so that you will have time to look and see what you have exposed before going on to the next cut. Stop every now and again and draw what you see. Again, leave space for labels, which will be added later. Remember, it is not a race! The longer you take over this activity (within reason) the more you are likely to learn.

<u>Assignment</u>:

In this section you have examined the structure of a sheep's eye. Turn to the introduction once more and read through "Joe's Eye" carefully. In the space below sketch a neat labelled diagram of a human eye.

Genetics - The Case of the Blue-Eyed Boy

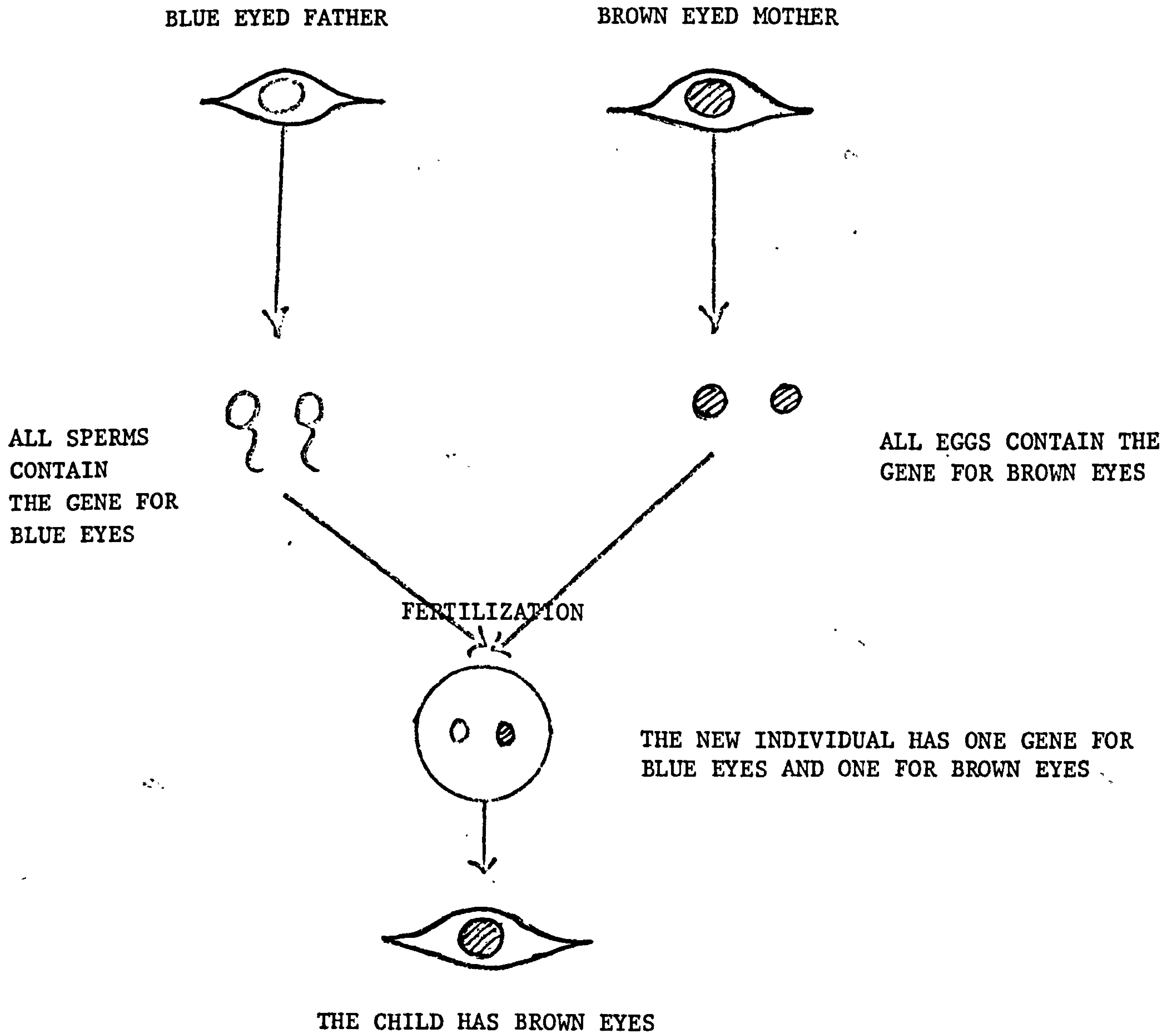
You may remember in the previous module "Hair" that hair colour was seen to be a hereditary trait, similarily with eye colour. Our eyes are coloured as a result of a ring of tissue called the Iris. The most usual colours are brown or blue although green and grey eyes are not uncommon.

The colour of our eyes like many other traits we have are controlled by GENES. Genes are very small structures which are part of the CHROMOSOMES, which in turn are found in the nucleus of cells.

For any given trait such as eye colour we possess two genes one of which originated from your father in his sperm cells and one from your mother in her egg cells. Sometimes they are the same and sometimes they are different from each other.

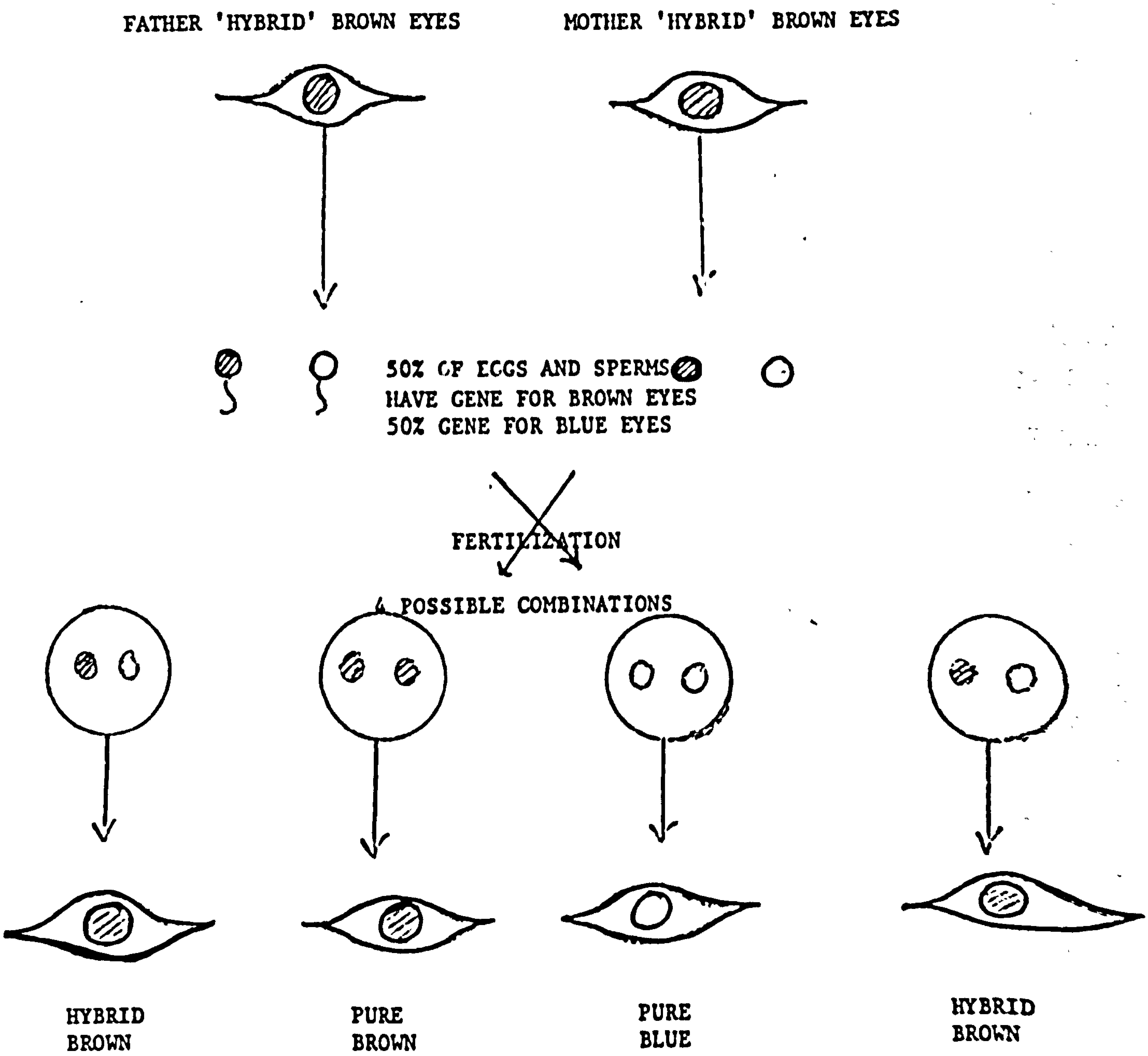
Let us suppose that a child has a father who is blue-eyed and all of the father's ancestors were blue-eyed as well. The sperm cells of the father then contain single blue-eyed genes. Let us also imagine that the mother was brown-eyed and all her ancestors were brown-eyed, then the mother's egg cells contain single brown eyed genes. During fertilization the sperm cells combine with the egg cells and the genes for eye colour form a pair, as do all the other genes for bodily traits. As the embroyo develops and the initial cell produced by fertilization reproduces itself, the gene pair is copied in al the cells so that all the gene pairs for eye colour are the same as the first pair. As the eye colour develops the gene pair controls the pigmentation. In the case of this child he will have brown eyes because the brown-eyed gene is stronger in its effect than the blue-eyed one. The brown-eyed gene is said to be DOMINANT and the blue-eyed gene RECESSIVE.

If both of the gene pair had been brown-eyed genes then the child would have had brown eyes and if both genes had been blue-eyed genes the child would have had blue eyes.



Thus a brown-eyed person could have an eye colour gene pair which was pure, both genes the same (brown-eyed) or hybrid, one gene blue-eyed and one gene brown-eyed! In both cases the person would have the same coloured eyes and it would be impossible to know whether he was pure or hybrid for eye colour.

So far we considered the case of two parents who were pure for eye colour. What if they were both hybrids and had brown eyes. In this case the sex cells (sperms and eggs) of the parents both contain a mixture of brown-eyed genes and blue-eyed genes. At fertilization the gene pair of the child can be any one of three possible varieties.



If the child has a pure brown-eyed gene pair or a hybrid pair he will have brown eyes. However, if he has a pure blue-eyed gene pair, then he will have blue eyes, inspite of the fact that both parents have brown eyes.

Assignment:

A Canadian Judge once ruled in a court of law that a blue-eyed boy was not the son of two people who had been killed in an accident and who had had brown eyes. Thus depriving the child of his inheritence. Later on he corrected his decision after he had been told a little about genetics.

Imagine you were a judge and a brown-eyed boy claimed to be the son of parents who were both blue-eyed, how would you rule? Explain why.

Project:

Conduct a survey on eye colour. Examine as many students as you can, and record the eye colour. Which are the most common colours?

III. PROPERTIES OF LIGHT I

You have already looked at the structure of the eye, a delicate organ which enables us to see. However without light, vision as we know it would be impossible. What light is, how it is produced and how it behaves are some of the topics we will deal with in this module. In this particular section we will consider sources of light and some of the simpler behaviours of light.

Sources of light

What artificial sources of light can you think of?

It was only towards the latter end of the nineteenth century that man had reliable sources of artificial light. What sort of effect on man and the way he lives do you think the advent of artificial light sources had? How would your life be different if you did not have an artificial source of light?

Why WE Cannot See Around Corners

One assumption we make in our day-to-day activity is that light travels in straight lines. After all, we walk straight towards a destination we can see, and we know we will arrive.

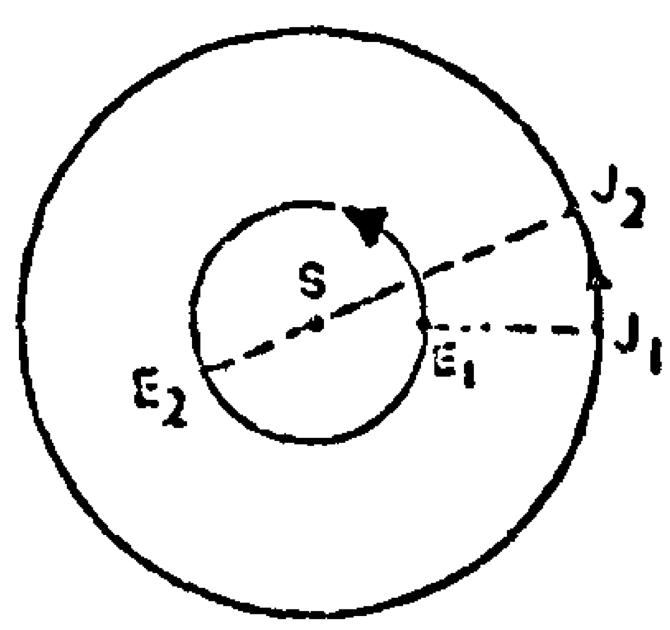
Punch a small hole in each of three pieces of cardboard. Arrange the pieces of cardboard so that an object can be seen by looking through the holes. How are the holes then arranged?

We make the assumption that light travels in straight lines in investigating the simpler properties of light, however, we will see later on that light does bend, but it is such a small amount that we do not notice it in the normal course of events.

The Speed of Light

It is hard for us to realize that light in fact has a speed of travel. After all we turn on a switch and the light is there! We do not wait for the light to travel across the room, it appears instantaneously. However, light does not travel instantaneously, it just appears to us to do so because of very high speed.

Although today scientists have measured the speed of light very precisely it is interesting to look at one of the first methods used as long ago as 1676 by a Danish astronomer Romer. He was observing the moons of Jupiter (they are easily observable with a modest telescope). Now the moons of Jupiter are eclipsed regularly, as they disappear behind Jupiter, and Romer from his observations was able to predict when the eclipses should occur.



However, he found that his predictions were wrong. If he made his observations when the Earth and Jupiter were at the nearest points, E_1 and J_1, he found that the predicted eclipse was late when viewed as the two planets were at their furthest separation, E_2 and J_2. He argued that the eclipse was late because the light from it had to travel a longer distance. In fact, the light has to travel across the diameter of the Earth's orbit.

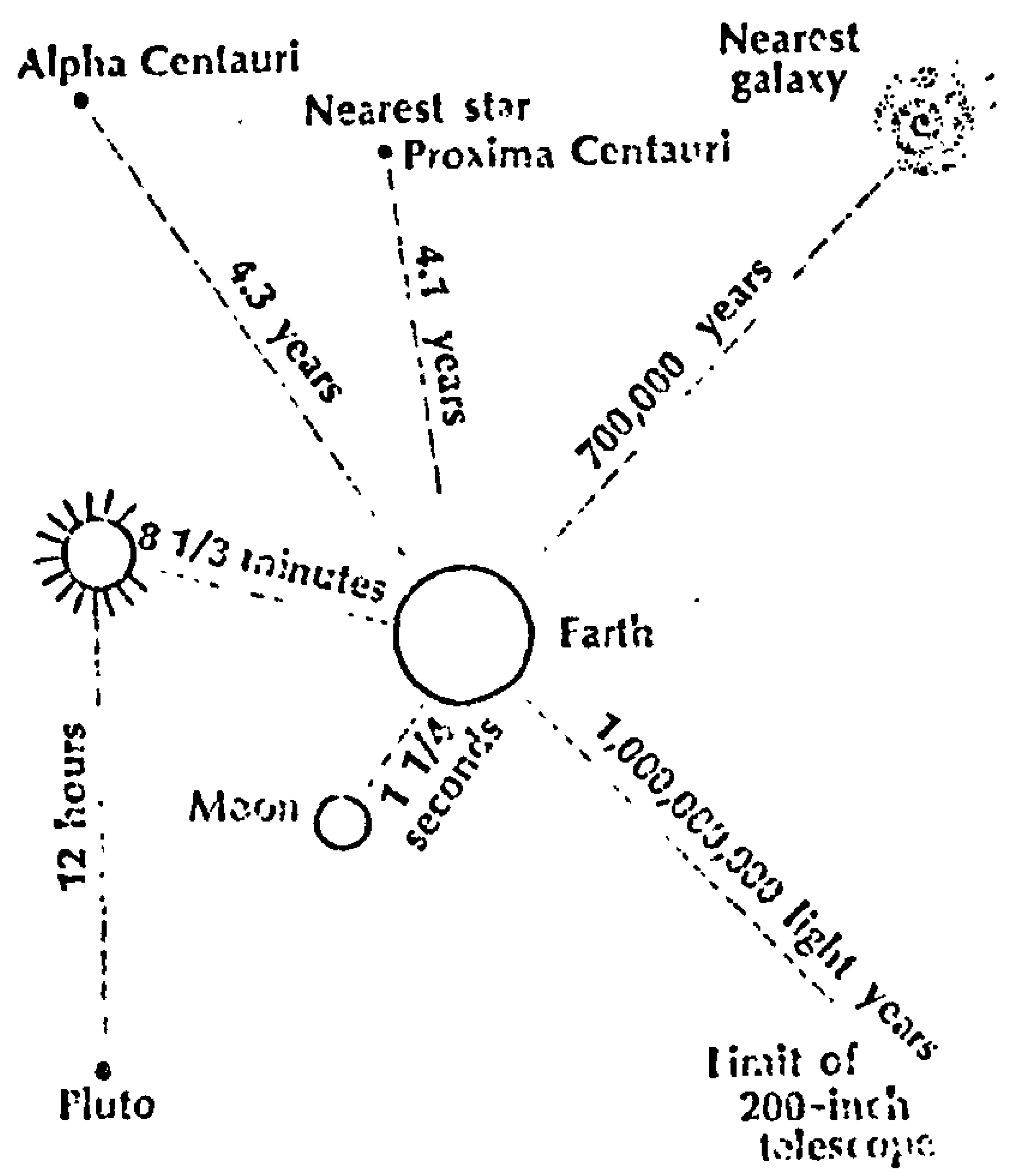
Romer found that the time lag was 22½ minutes and the diameter of the Earth's orbit was 186 million miles.

Using his figures calculate the speed of light.

Today accurate measurement gives the speed of light as 186,200 miles per second. Astronomers make use of the speed of light when discussing the distant objects of the heavens. They use the term <u>light year</u> as an astronomical unit of distance, it is the distance travelled by light in a year.

Assignment:

The diagram below shows astronomical distances measured in light years.



1. How many miles in a light year? Show calculation.

2. How many miles are we from Alpha Centauri?

3. How many miles are we from Proxima Centauri?

4. How long would it take light to travel from Gander to St. John's? Assume the distance between them is 200 miles.

5. When you look at the stars, are they where you see them?

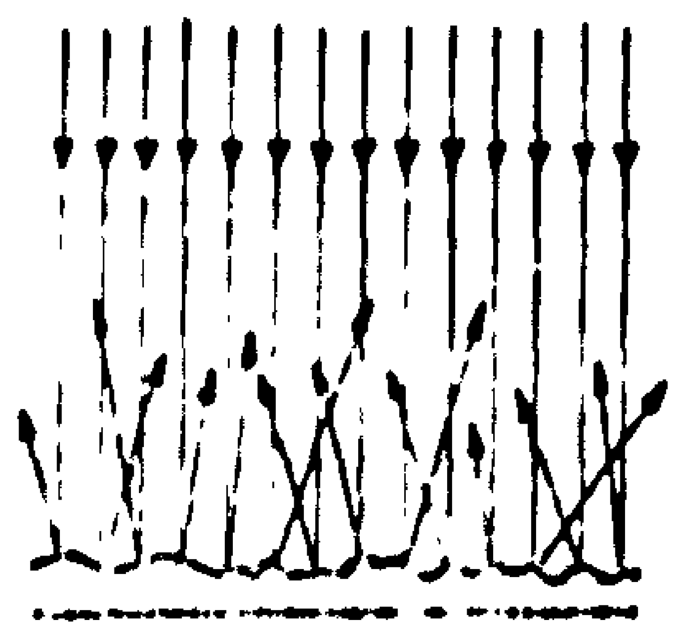
Reflection

It is easy enough for us to see a fire or an electric bulb since these objects are giving out light. However, how is it we see a table or a chair or each other? The answer, of course, is that objects reflect light. Light bounces off objects in much the same way as a ball bounces off a wall. However, not all objects reflect light equally.

Hold a candle near the different surfaces e.g. wall, mirror, blackboard. Which surfaces seem to reflect light the best, i.e. gives the clearest image of the candle?

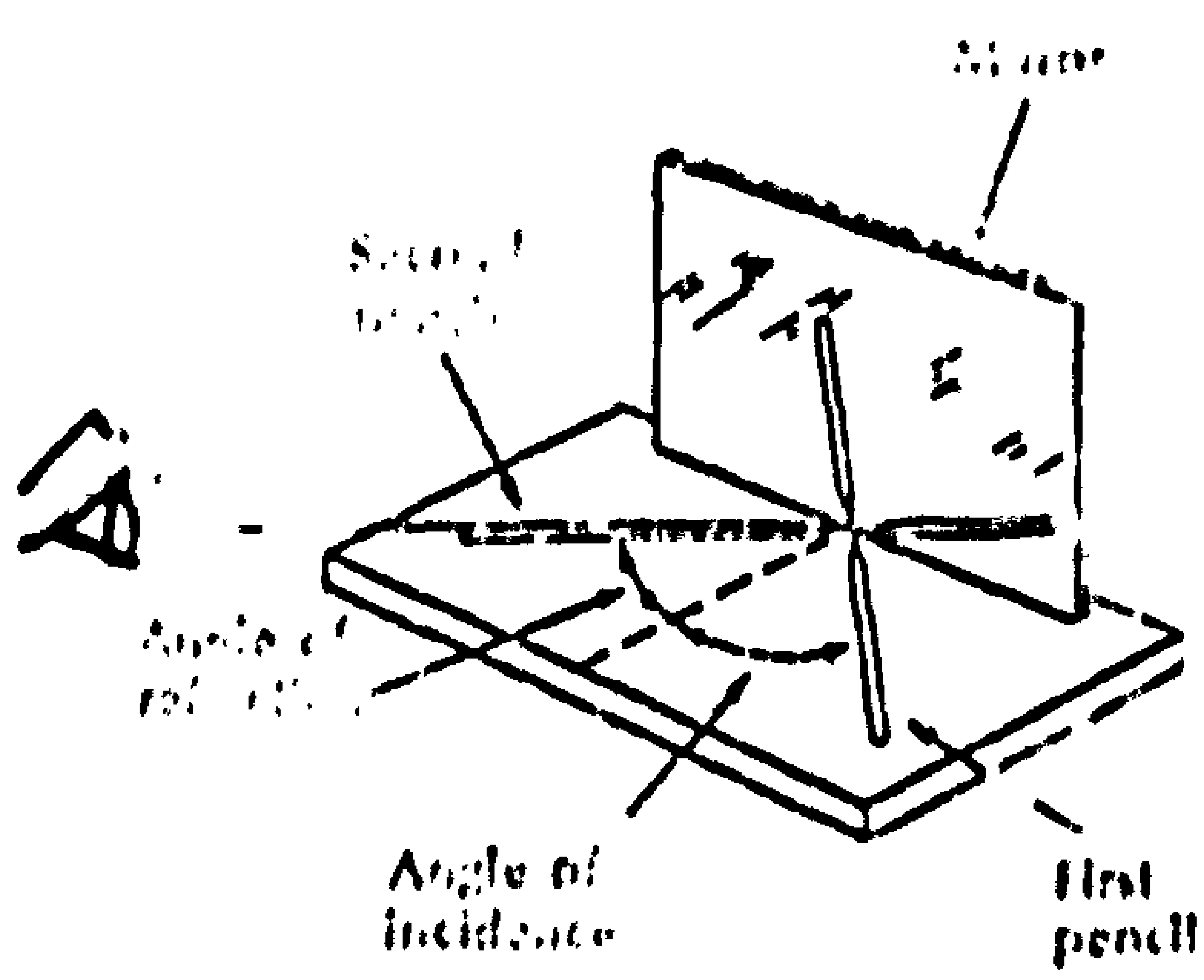
Rough surfaces do not reflect light very well. The diagram below explains why.

Light is diffused from rough surfaces.



The light that is reflected from a rough surface is reflected in all directions and is said to be scattered or diffuse. If the light from an object reaches our eyes in such a manner that it is concentrated in a particular direction, we experience a glare which is uncomfortable on the eyes. What steps are taken to reduce glare in everyday life?

If we are driving along and we look in a mirror we can see behind us and we know that our view is accurate. You may also have seen someone perform some kind of stunt, such as firing a gun while looking in a mirror. This suggests that when light is reflected it obeys a regular law or principle.



Fix a mirror so that it is in an upright position, a piece of plasticine will help you do this. Place a pencil on the table as shown in the diagram so that it makes an angle to the mirror, with the point touching the mirror. Look into the mirror and place a second pencil so that it is directly in line with the image of the first as seen in the mirror. Draw a perpendicular line to the mirror at the point where the ends of the pencils touch the mirror. Compare the angles formed by each pencil and the perpendicular line.

Now it would be wrong of us to make any statement about a law of reflection on the basis of just one result. Why?

Your teacher will help you to decide what else you must do before we can state a law of reflection.

Hold a mirror up in front of your face. Move it towards you, then back. What happens to the image in the mirror?

Again look at yourself. Wink your right eye. Which eye winks back? What else then can we say about images formed in mirrors?

In some parts of Canada ambulances have the word written as

ƎƆИA⅃UᗺMA

on the front. Why do you think this is?

Assignment:

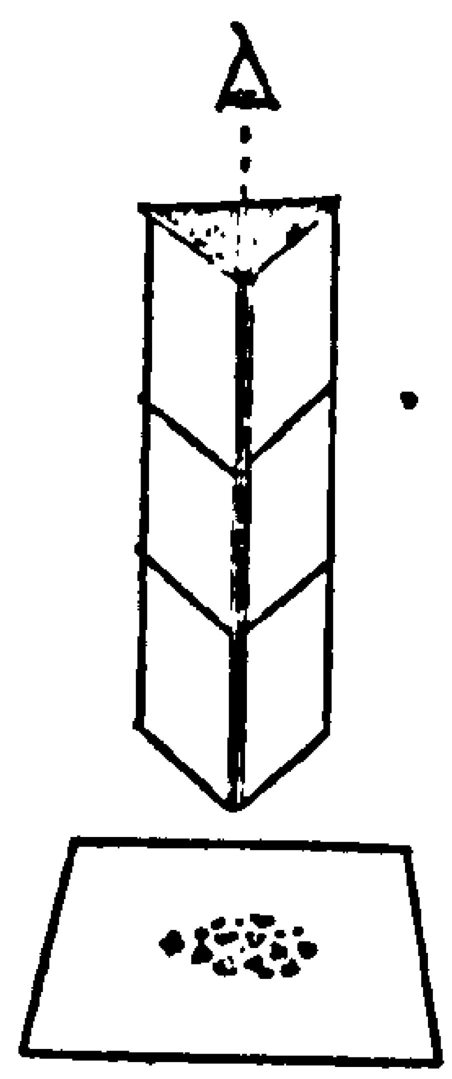
A man 2 metres tall stands 2 metres away from a wall on which there is a mirror. What is the smallest size mirror which will enable him to see his whole body? Solve the problem by using a scale drawing.

Project:

Although we have only briefly looked at mirrors many optical instruments make use of mirrors and reflection. Below are details of two simple optical instruments a periscope and a kaleidoscope which can be made using strips of mirror.

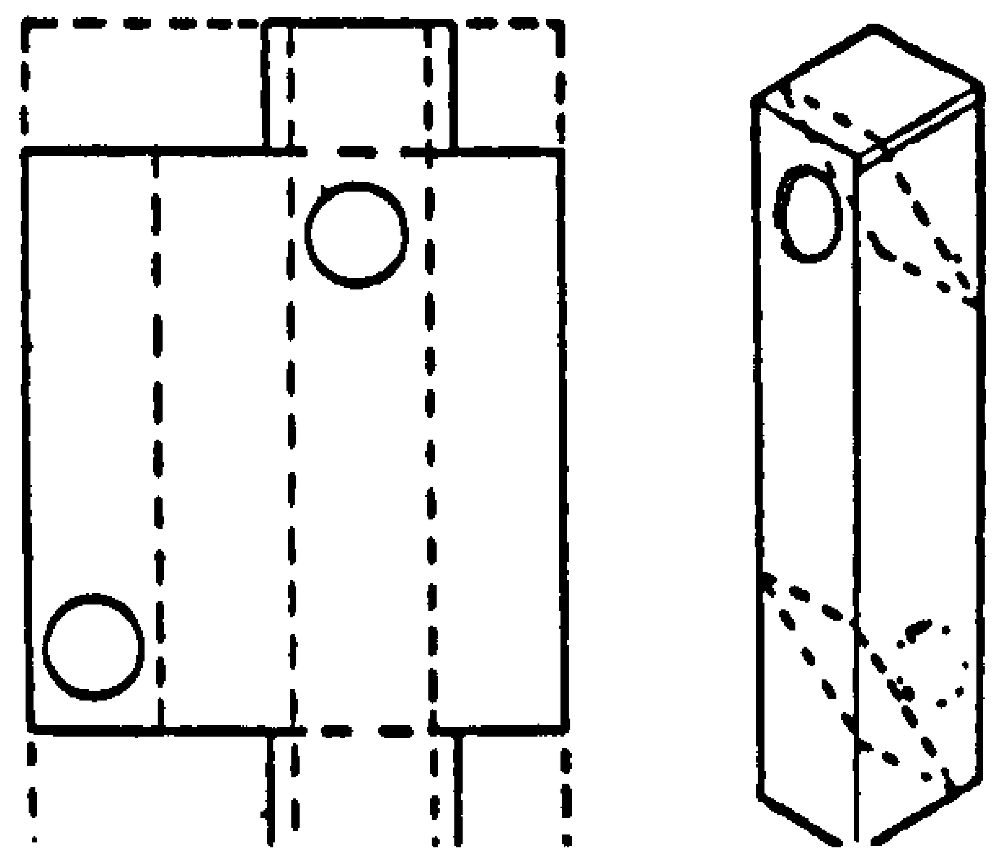
How to make a kaleidoscope

Fasten together two slips of mirror about 10 cm by 3 cm and a piece of card the same size, with a rubber band or gummed paper. Look down the axis of the triangular prism so formed. Objects viewed through it will form a regular pattern. If silvered glass is not available, black paint on the outer side of plain glass will give quite good results.



How to make a model periscope

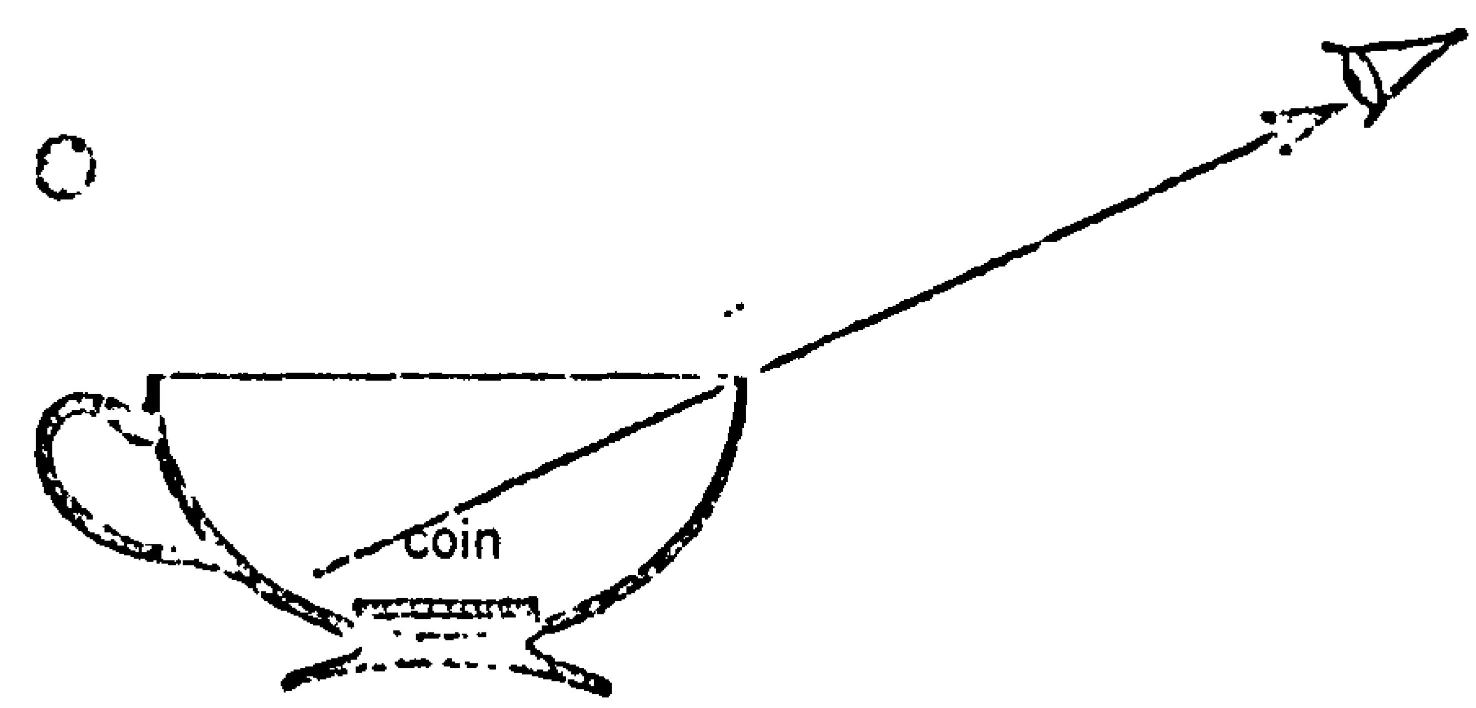
Score three lines parallel to the long side of a postcard and 2 cm apart. These will divide the card into four strips. Cut away pieces from the ends 2 cm wide as shown in the diagram. Cut holes in the positions shown, using a cork borer, and then fold up the card into a rectangular box. Stick small pieces of mirror opposite the apertures, using plasticine or gummed paper.

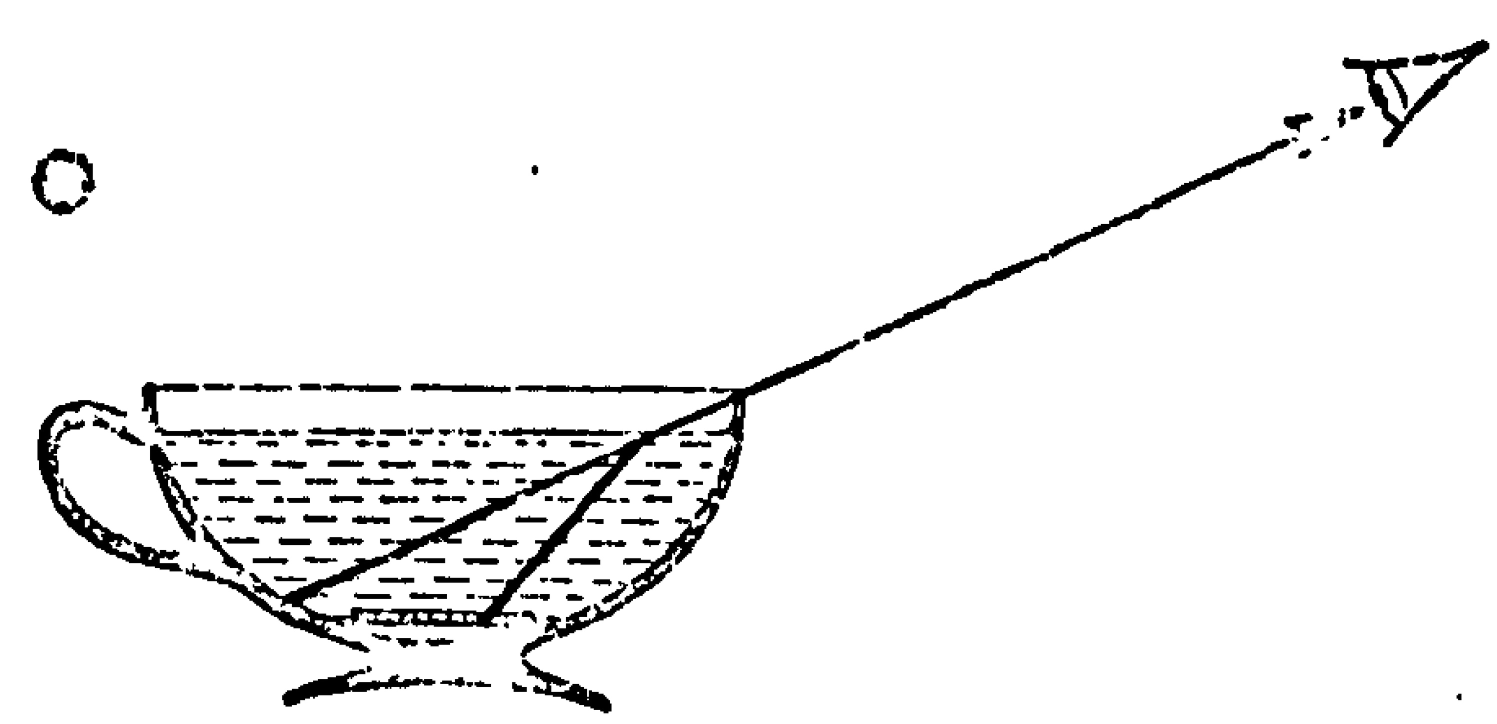


Refraction

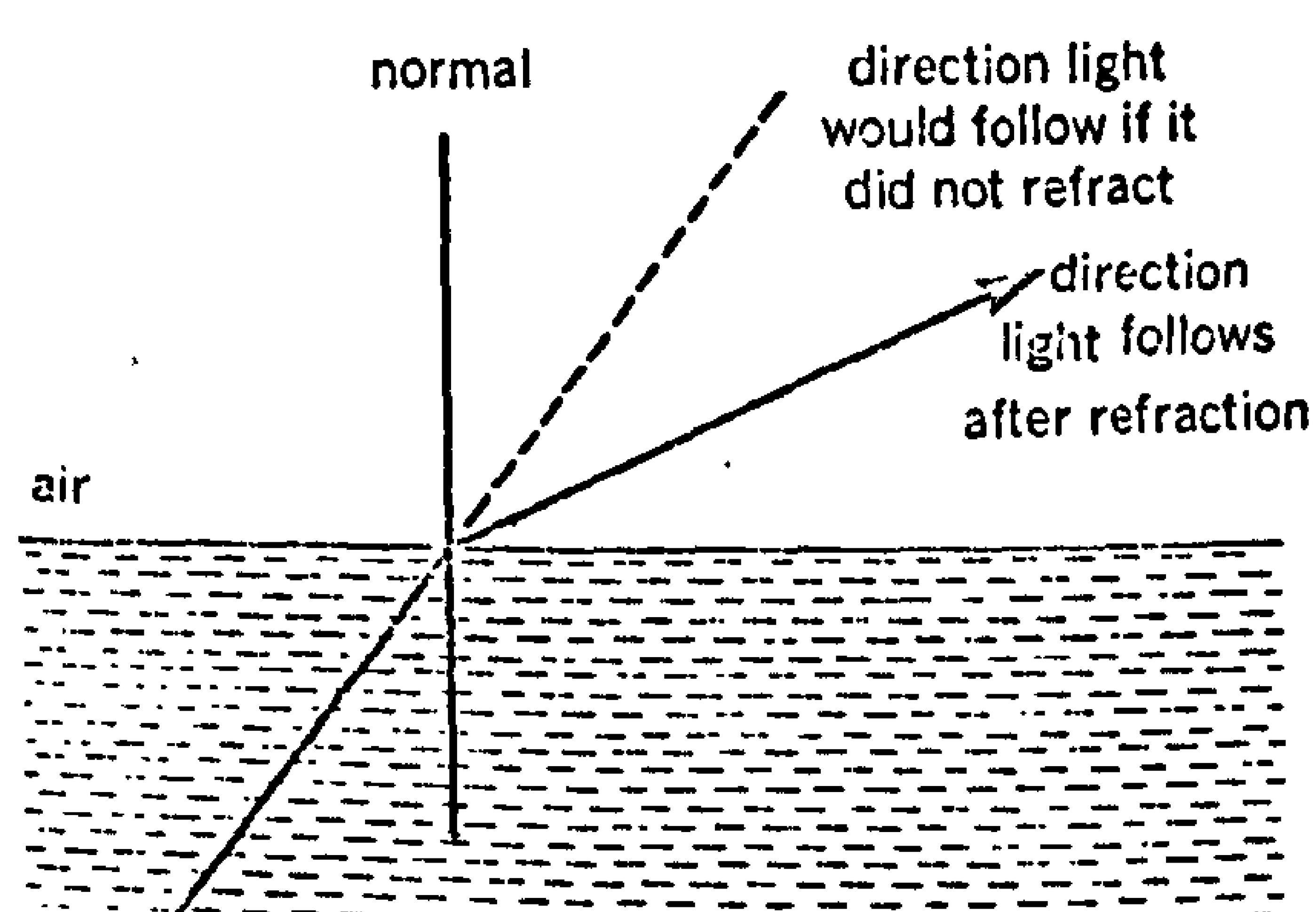
Although earlier on we saw that light travels in straight lines, we can, with a little help, make it bend.

Place a coin in the bottom of an empty cup so that it is just out of sight of the viewer, as shown in the diagram. You cannot see the coin because a straight line (remember light travels in a straight line) cannot be drawn between the eye and the coin. Now carefully fill the cup with water, you will see the coin suddenly appear although it is still in the same place. This is because light rays from the coin have been bent at the water surface so that they do enter the eye.

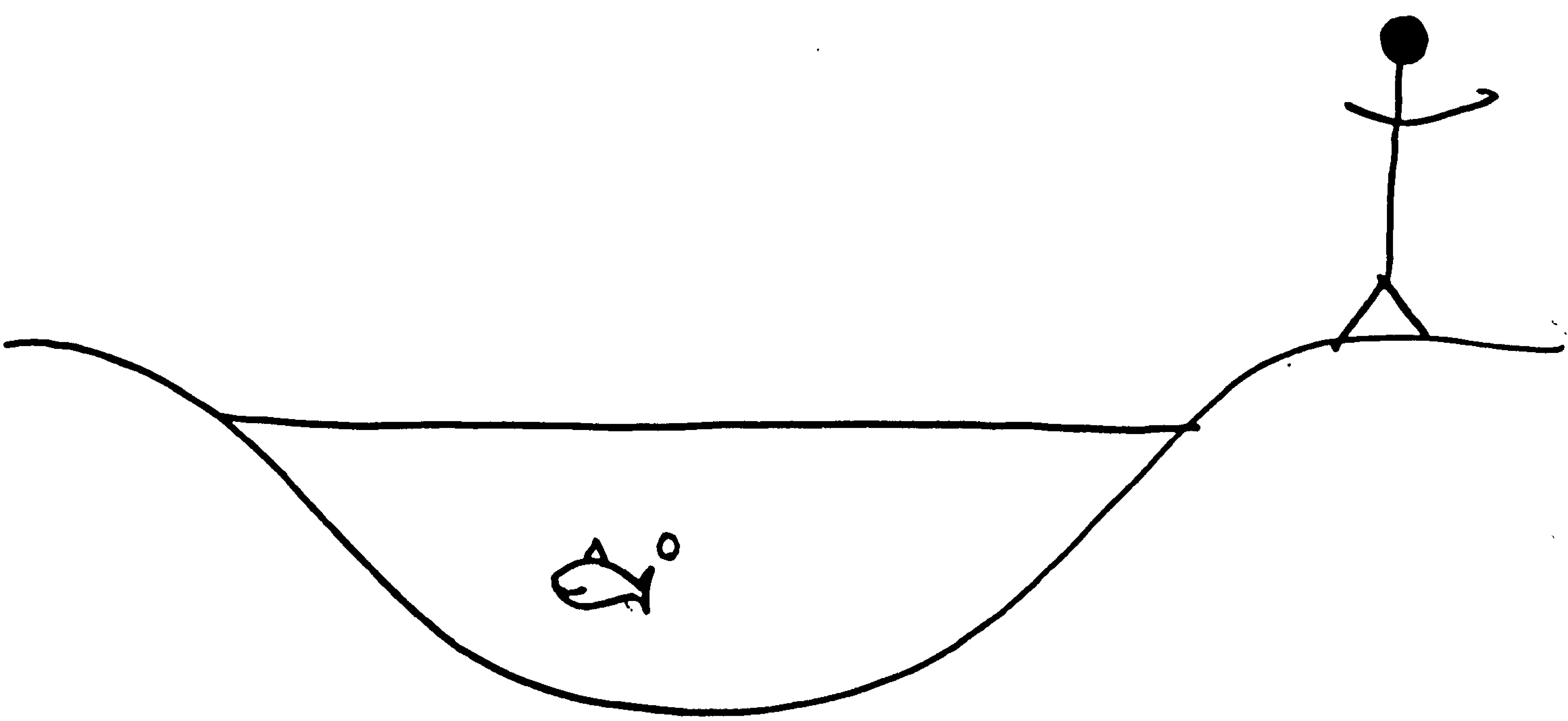




Thus we see that light can bend as it passes from one substance to another. In the case of the coin and cup trick the light bent as it passed from water to air, as shown below.



If you have ever tried to throw a stone at an object at the bottom of a pond, you will soon realize that you must compensate for the bending of light.



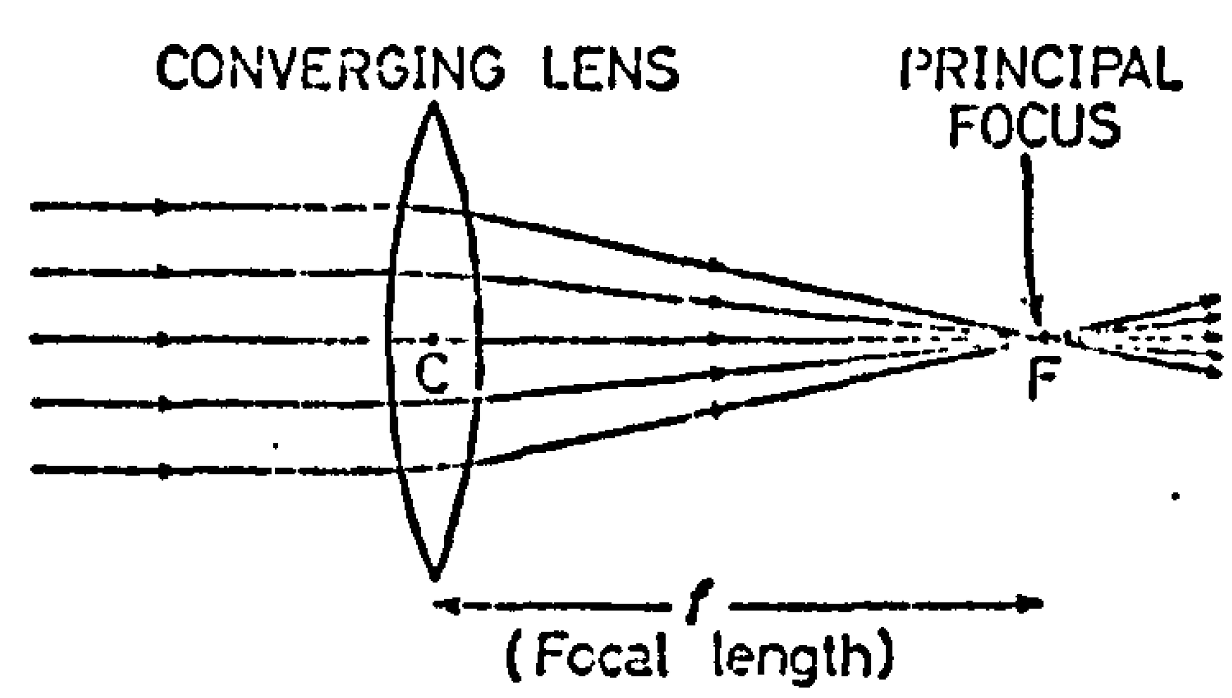
Draw a line to show the path a ray of light takes from the object O to the eye.

The bending of light as it passes from one medium to another is termed REFRACTION and is caused by the light changing speed as it passes from one substance to another.

The most important application of REFRACTION to man is in the use of lenses which are usually made from glass or plastic.

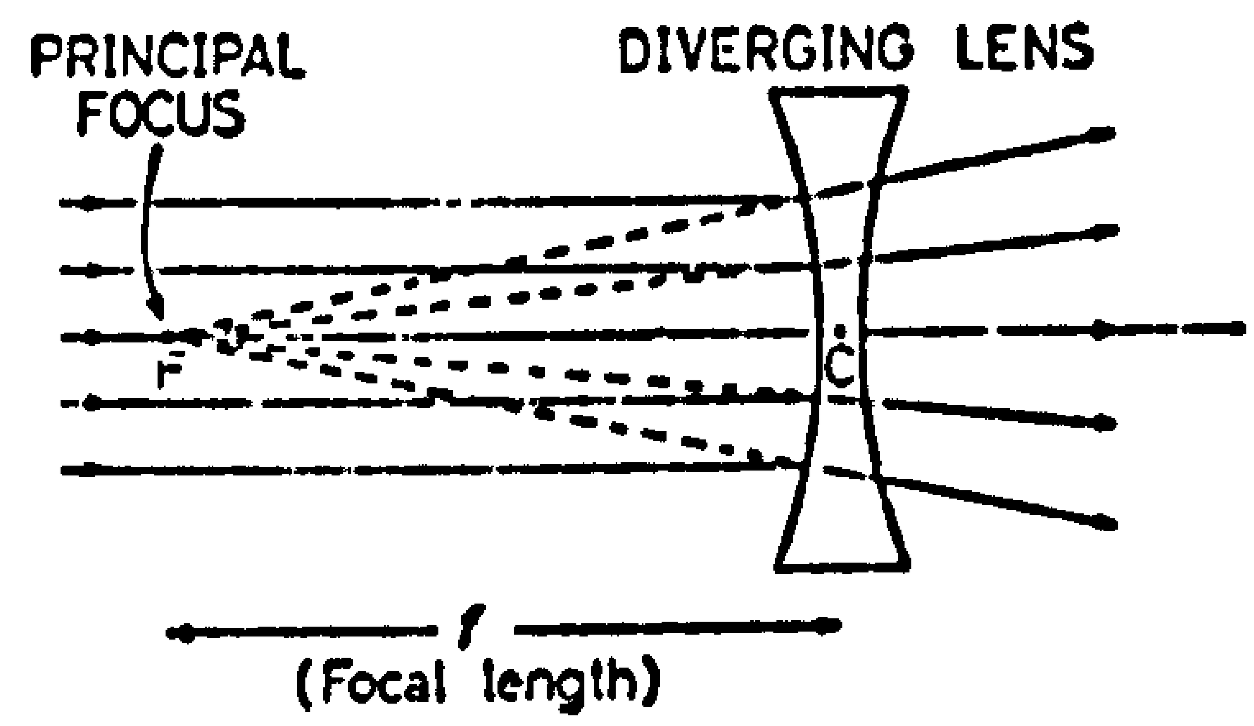
You have a selection of lenses. Examine them carefully. You will note there is a variety of shapes and sizes, however, we can make a simple classification based on their behaviour with light. Hold each lens in the rays of light from a distant source and attempt to focus the light onto a piece of paper. Divide the given lenses into two groups. Those with which you were able to focus the light and those with which you were unsuccessful.

If you examine the lenses in the group which you were successfully able to focus light with, you will see they are thicker at the centre than at the edges. These are called <u>convex</u> or converging lenses. The diagram below shows the path that rays of light take as they pass through the lens.



The group with which you were unsuccessful in your attempts to focus light are called <u>CONCAVE</u> or <u>DIVERGING</u> lenses. You will note that these are thinner at the centre than at the edges. The diagram below shows the path of rays of light as they pass through such a lens.

You can see why you could not focus light with such a lens.



Because lenses are so important to us, from the standpoint of our eyes, and the workings of optical instruments, let us examine the types of images that lenses form.

Select a convex lens and again use it to focus light from a distant source onto a sheet of paper. This time measure the distance of the lens from the paper when it focusses the light to a sharp point. This distance is an approximate measure of its focal length, an important characteristic of the lens.

Focal Length = ______________ cm.

Using a candle as an illuminated object arrange it a distance away from the lens such that the distance is greater than the focal length of the lens. On the opposite side of the lens use a sheet of paper as a screen and move it until you obtain an image clearly focussed.

Is the image the right way up?

An image which can be focussed on a screen is said to be a Real Image.

Repeat the above experiment with the candle placed so that it is nearer to the lens than the focal length. Try once again by moving the paper screen to obtain an image. Do you succeed?

Remove the paper and look through the lens at the candle. Describe what you see.

This type of image is a VIRTUAL IMAGE and cannot be focussed onto a screen. You will notice that in this case the image is larger, and here the lens is being used as a magnifying glass.

Replace the convex lens with a concave lens and repeat the last experiment again trying to locate the image with the sheet of paper. Do you succeed?

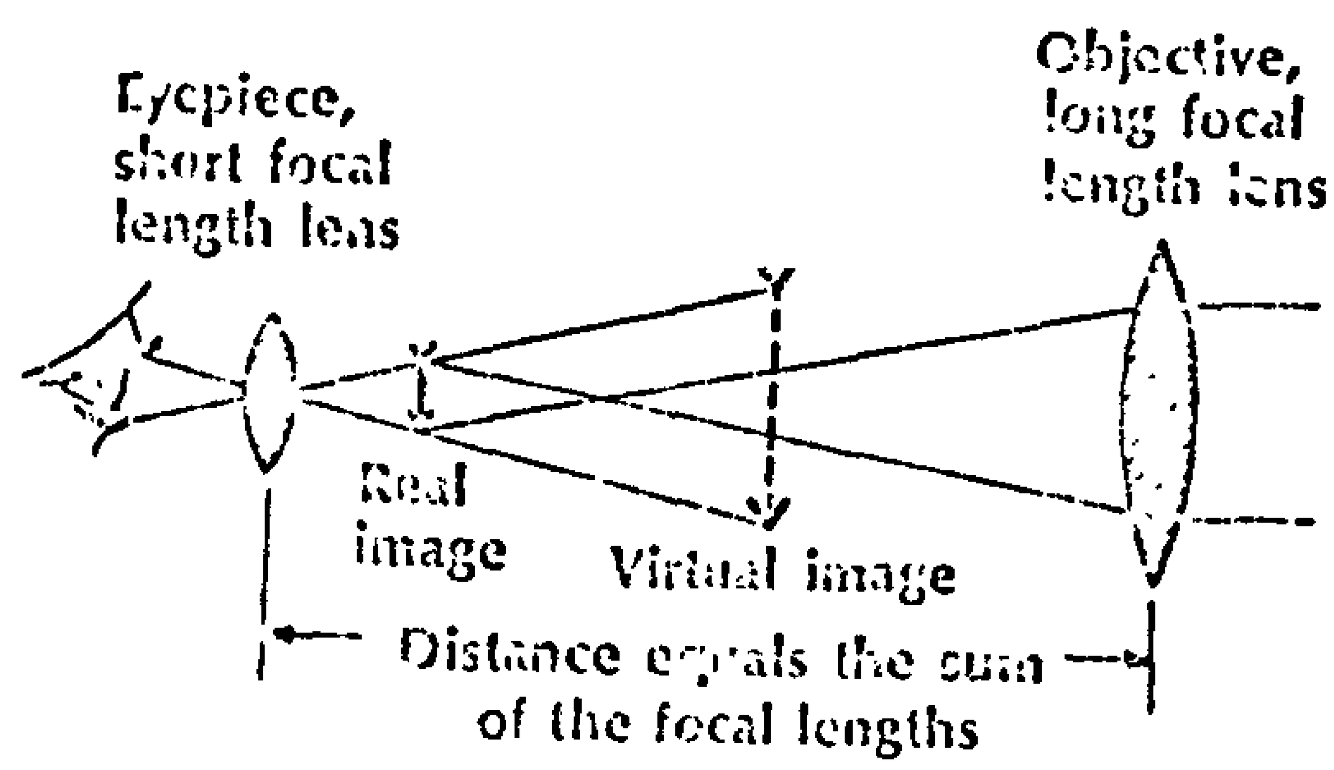
What sort of images do concave lenses form?

Summarize below what you have found out about the types of images formed by the two types of lens.

Many optical instruments use lenses in their construction, some are very complicated and require complex lens systems. However, there are simple instruments that you can make.

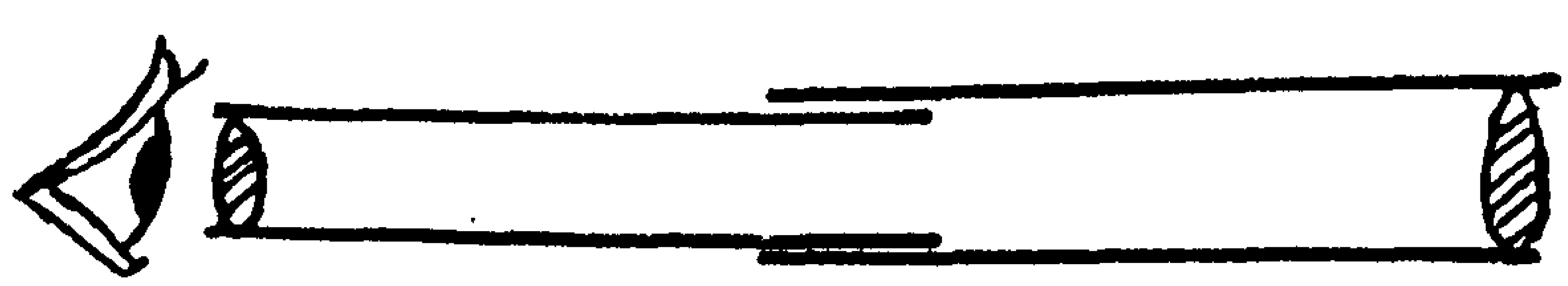
Project:

In order to construct a simple telescope you need two converging lenses. One of fairly short focal length and the other of long focal length. Place the short one near to the eye and the second lens a distance away equal to the sum of the focal lengths.



Telescope.

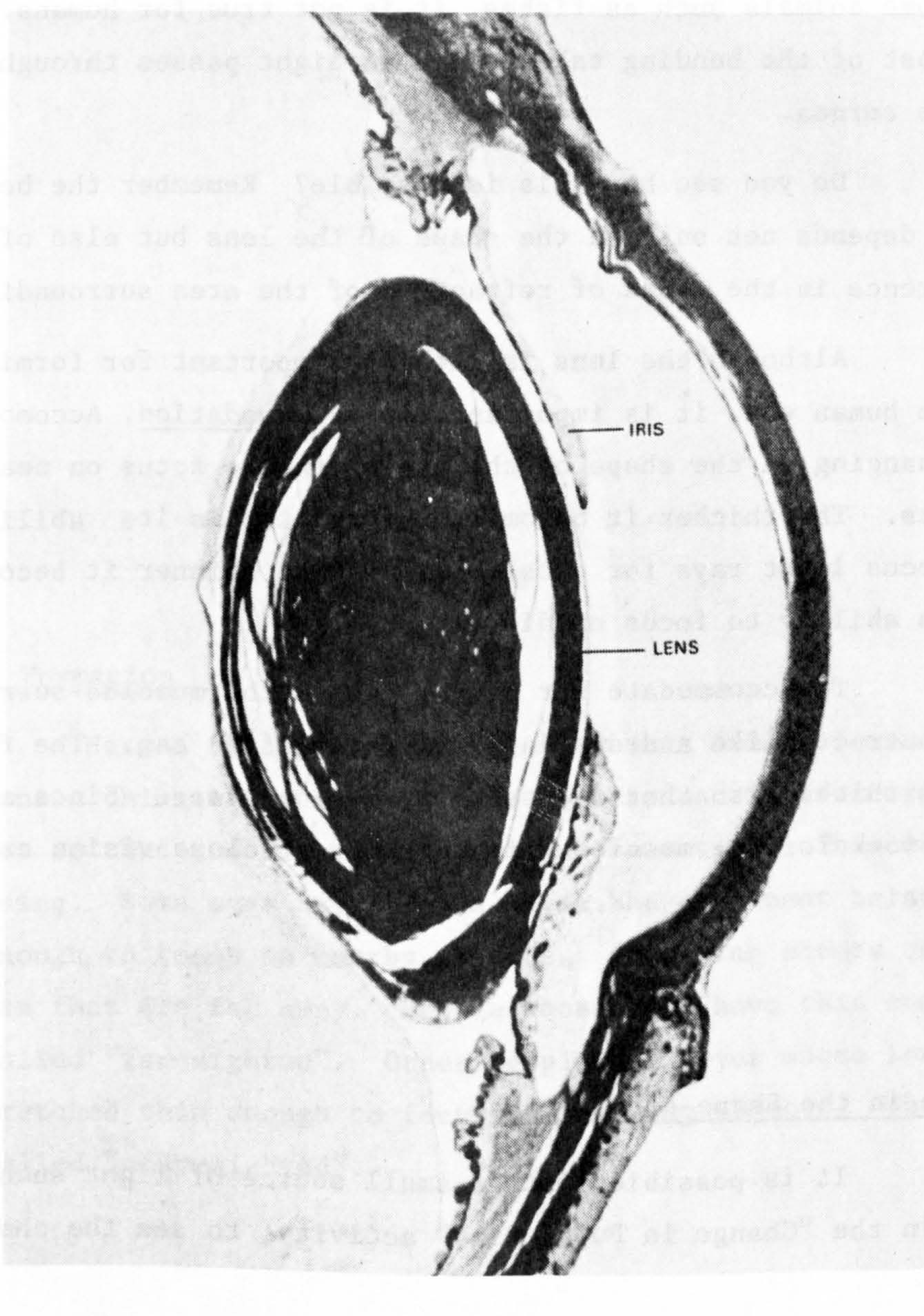
A more permanent arrangement can be made by mounting the lenses in cardboard tubes such as are found in the centre of paper towels. Two such tubes, one mounted on another as shown, will allow for focussing.



IV. THE FUNCTION OF THE EYE (I)

In the previous sections we have made some basic observations of our eyes. We have examined the structure of the eye, and we have looked at some basic properties of light. We are now ready to examine the functions of certain parts of the eye, in particular the lens and surrounding area. In the next section we will examine some additional properties of light, in particular, colour, and then go on to examine the function of the retina in image formations.

The Lens and Surrounding Area



In the previous section on the properties of light we examined some of the basic characteristics of lenses. You know for example, that a convex lens converges light while a concave lens diverges light. Now you can apply these principles to a study of the lens and surrounding area of your eye.

The unusual photograph on the previous page (taken from the Life-Science book, Light and Vision) shows a cross section of the lens, iris and cornea magnified about nine times.

From your previous study you might expect that light would be bent most as it passes through the lens of the eye. While this is true for some animals such as fishes, it is not true for humans. In the human eye most of the bending takes place as light passes through the surface of the cornea.

Do you see how this is possible? Remember the bending of light depends not only on the shape of the lens but also of the difference in the index of refraction of the area surrounding the lens.

Although the lens is rather unimportant for forming the image in the human eye, it is important for accommodation. Accomodation is the changing of the shape of the eye's lens to focus on near and far objects. The thicker it becomes, the greater is its ability to converge and focus light rays for close vision. The thinner it becomes the greater is its ability to focus on distant objects.

To accommodate for nearby vision the muscles surrounding the eye contract, like a drawsting closing a duffel bag. The flexible lens bulges thicker, so that focussing power increases. Since accommodation means work for the muscles, long periods of close vision can result in eyestrain.

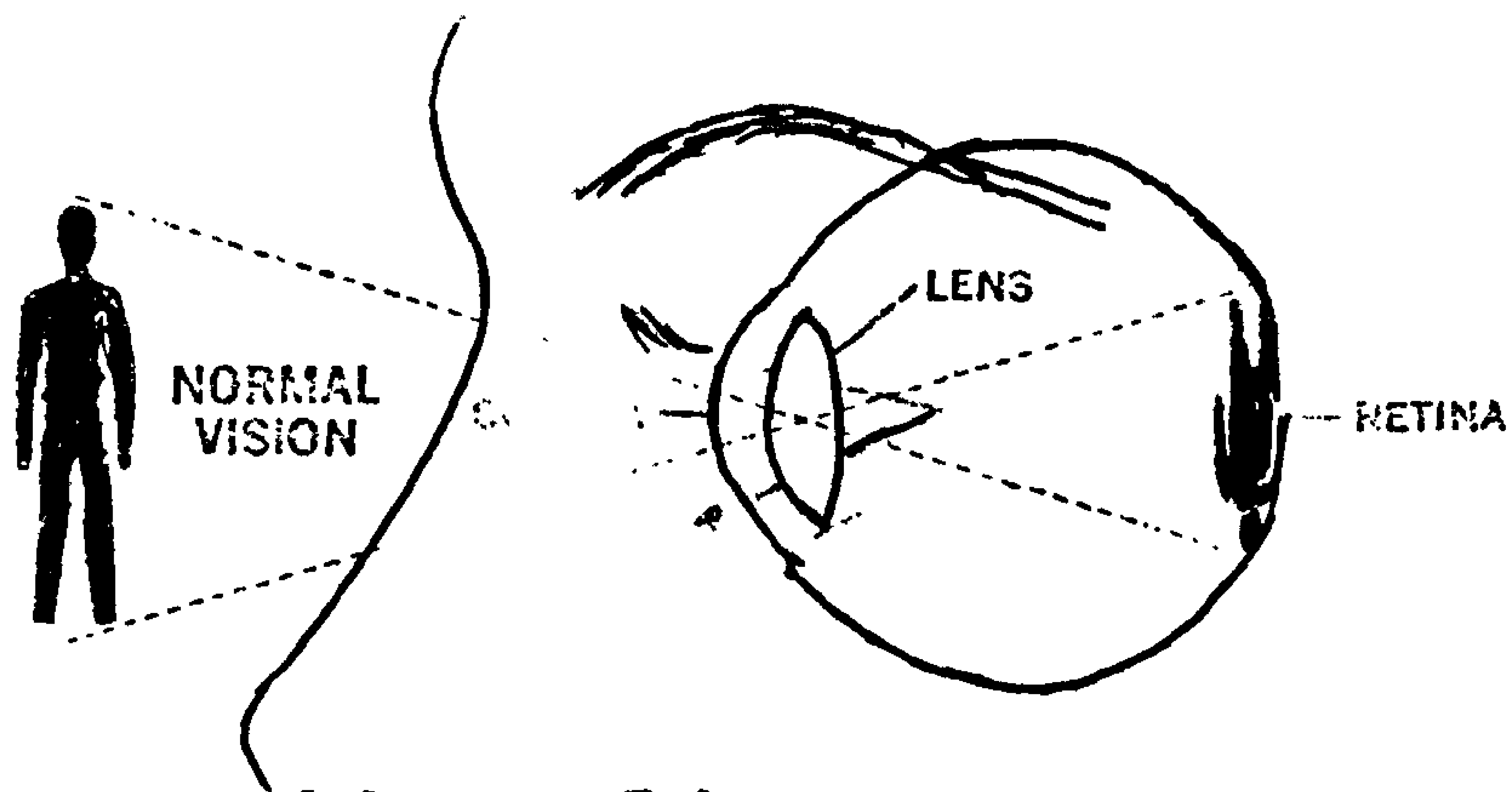
Change in the Shape of the Lens

It is possible, with a small source of light such as that used in the "Change in Pupil Size" activity, to see the changes in shape of your partner's lens as he accommodates to different distances. If the light is held in a suitable position it can be seen reflected from the eye. But there is not just one reflection. There are three. One reflection is from the cornea, one from the front of the lens, and one from the back of the lens. As the lens changes its shape the images change in size. Have your partner focus first on a nearby object and then, without moving his eyeball, focus on an object far away. Do you notice a change in the size of the reflected image? Note your observations below.

Image Formation

Normal eyes have muscles and lenses adaptable enough to make the lenses thinner for farther away objects and fatter for nearer objects so that the image will fall on the retina. This is called focussing. Some eyes have lenses whose shapes cannot be squeezed fat enough to focus on nearby objects. Focussing occurs only for objects that are far away. People whose eyes have this common defect are called "far-sighted". Other people have eyes whose lenses cannot be stretched thin enough to focus on far away objects. These people are called "near-sighted".

The short article on the next few pages, from a Reader's Digest reprint, describes in an interesting way these common problems and how they are corrected.



How Glasses Help You to See

Harland Manchester

THE CAMERA and the human eye are much alike. In each, a lens does three things: (1) focuses the light from an object, (2) passes the light through a lightproof chamber, and (3) forms an upside-down picture at the back of the chamber.

The human eye is much faster and more complete than the best camera. The eye adjusts itself and focuses itself. It takes both still and motion pictures in black-and-white or color, sending them along to the brain. There, in a fraction of a second, the picture is "developed and printed," enlarged to life size and turned right side up.

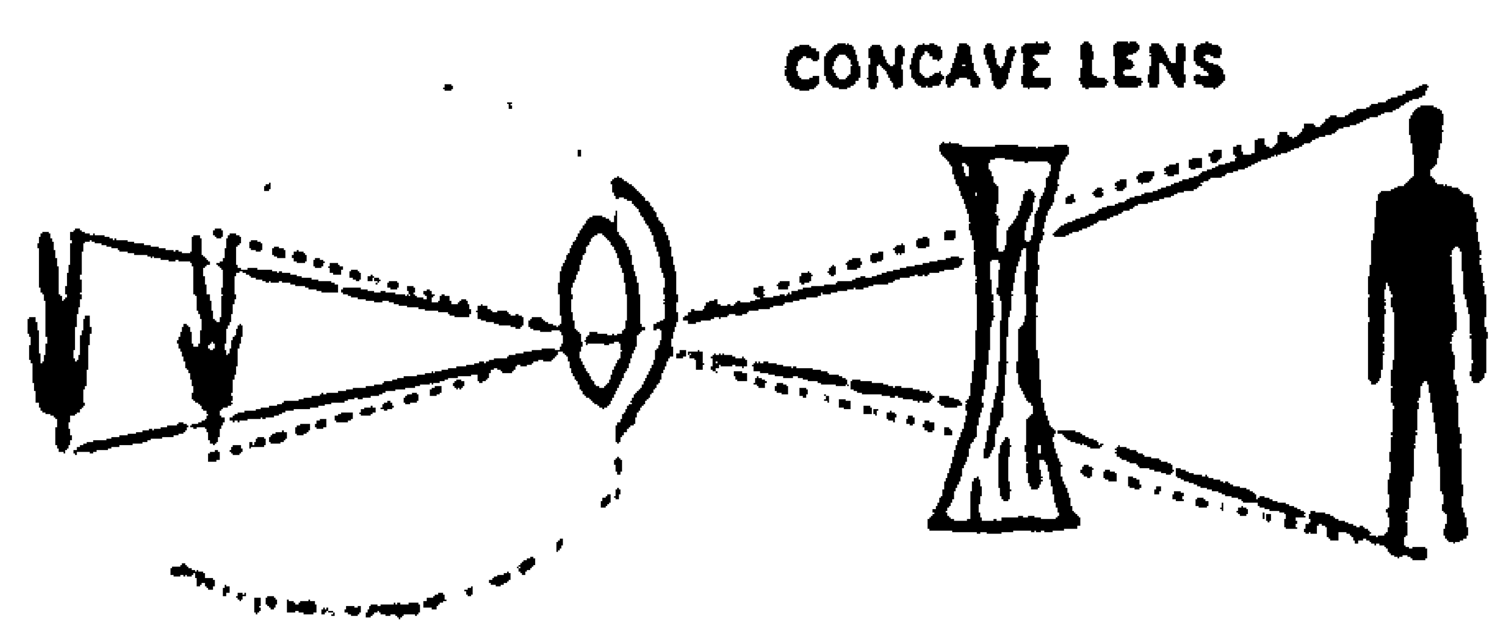
The eye and the camera focus in different ways. The camera lens is moved forward or backward until a sharp image falls exactly on the film. If an image falls in front of or behind the film, the photograph will be fuzzy.

But the lens of the eye does not focus by moving forward or backward. Instead, a muscle in the eye changes the *thickness* of the lens! For example, the lens is *thickened* to look at nearby objects. It is made thinner to focus on objects far away. The lens focuses light upon the *retina*. This back part of the eyeball is sensitive to light.

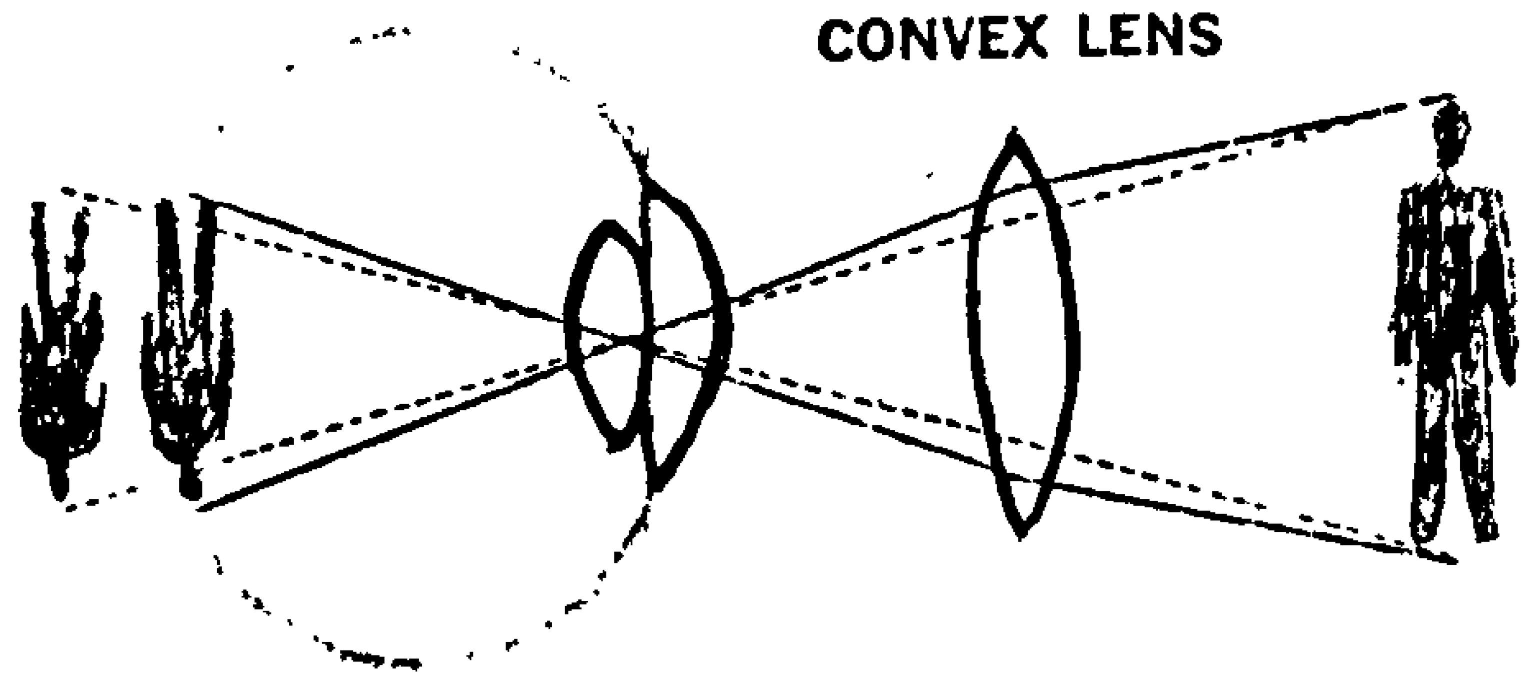
What happens if the length of the eye from front to back is too long or too short? The lens cannot change enough to adjust to all distances. So the eye takes fuzzy pictures except at a certain distance. Persons with such eye defects need glasses to see well.

If the eyeball is too long, near objects look clear to the person, but objects far away look fuzzy. We say that such a person is *nearsighted*. Faraway objects are out of focus because their image falls in front of the retina.

To place the image on the retina, glasses with concave lenses are used. A concave lens, thin at the middle, makes light rays bend less sharply. Thus the image falls on the retina, where it should.



Red line shows how concave lens corrects nearsightedness



Red line shows how convex lens corrects farsightedness

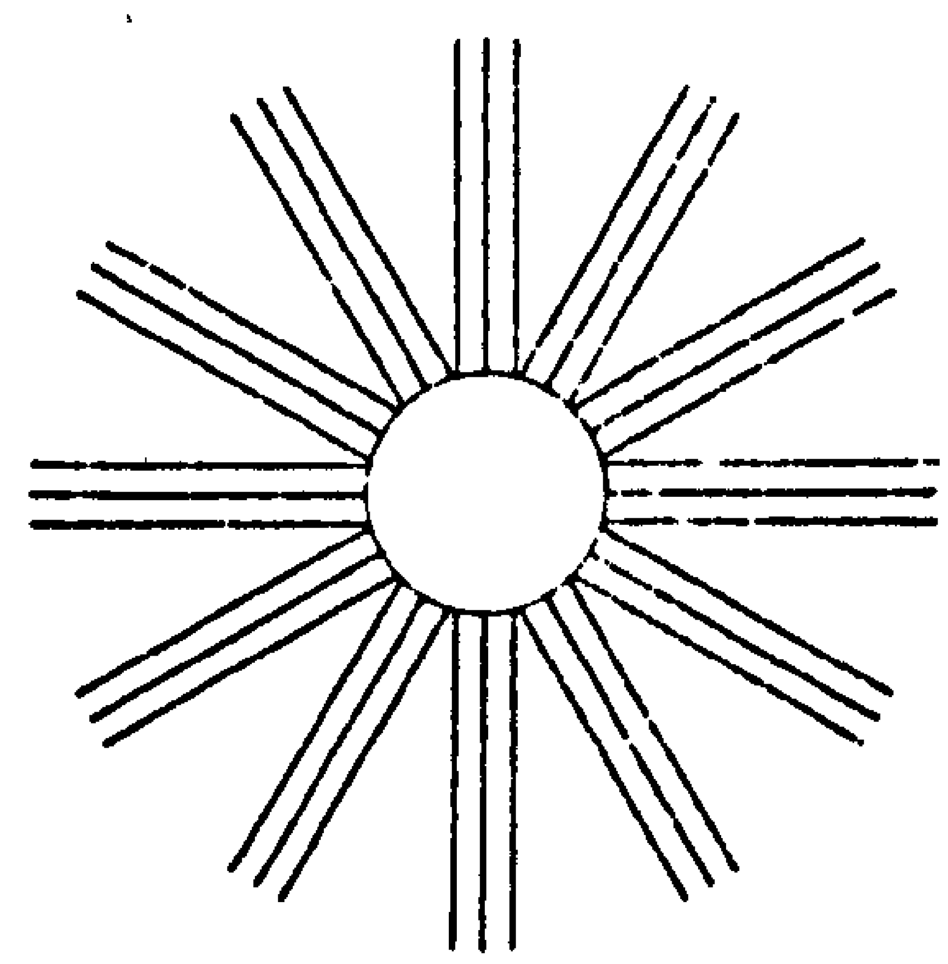
A *farsighted* person can see clearly objects that are far away. To him, nearby objects look fuzzy. His eyeball is too short for a sharp image to form on the retina.

The farsighted person needs glasses with convex lenses. As the diagram shows, a convex lens is thicker at the middle than at the edge. It bends light sharply, to focus a clear image on the retina.

Another common eye defect is astigmatism. It occurs when the outer part of the eye (the cornea) or the lens of the eye happens to be not perfectly round. If either is spoon-shaped, a person sees a blurred image.

You can test yourself for astigmatism by looking at the wheel diagram. Cover each eye in turn. If some spokes look black, the rest gray, the eye is astigmatic.

Astigmatism is corrected by a lens that is curved to make up for the spoon shape.



Astigmatic Test

Assignment:

The following short activities are based on the material in this section.

1. Take some concave and convex lenses from your lens kit and see what effect they have on your ability to focus on near and far objects. Note your observations in the space below.

2. What kind of glasses will correct near-sightedness? far-sightedness? Sketch diagrams below to show that you understand the lens set-up in each case.

3. What happens to the size of the image formed on the retina when the object is moved farther away? Experiment with diagrams if you like.

Project:

Find out what you can about contact lenses, how do they differ from eyeglasses. If you know anyone who wears contact lenses, find out how they use them, and any difficulties they encounter.

V. PROPERTIES OF LIGHT (II)

Earlier in this module we saw some of the simpler properties of light, however, we did not really consider what light is and how it is produced. The early Greeks thought that light was composed of a stream of particles travelling at high speeds. This theory is not too far removed from modern thought. Today scientists have a dual view of light. Light is composed of packets of energy, called photons, which travel at a very high speed. Can you recall what that speed was?

However, it is also found that light has properties which suggest that it travels in waves. Now you will be familiar with water waves and will realize that water waves carry energy, after all they wear away rocks and can move large objects.

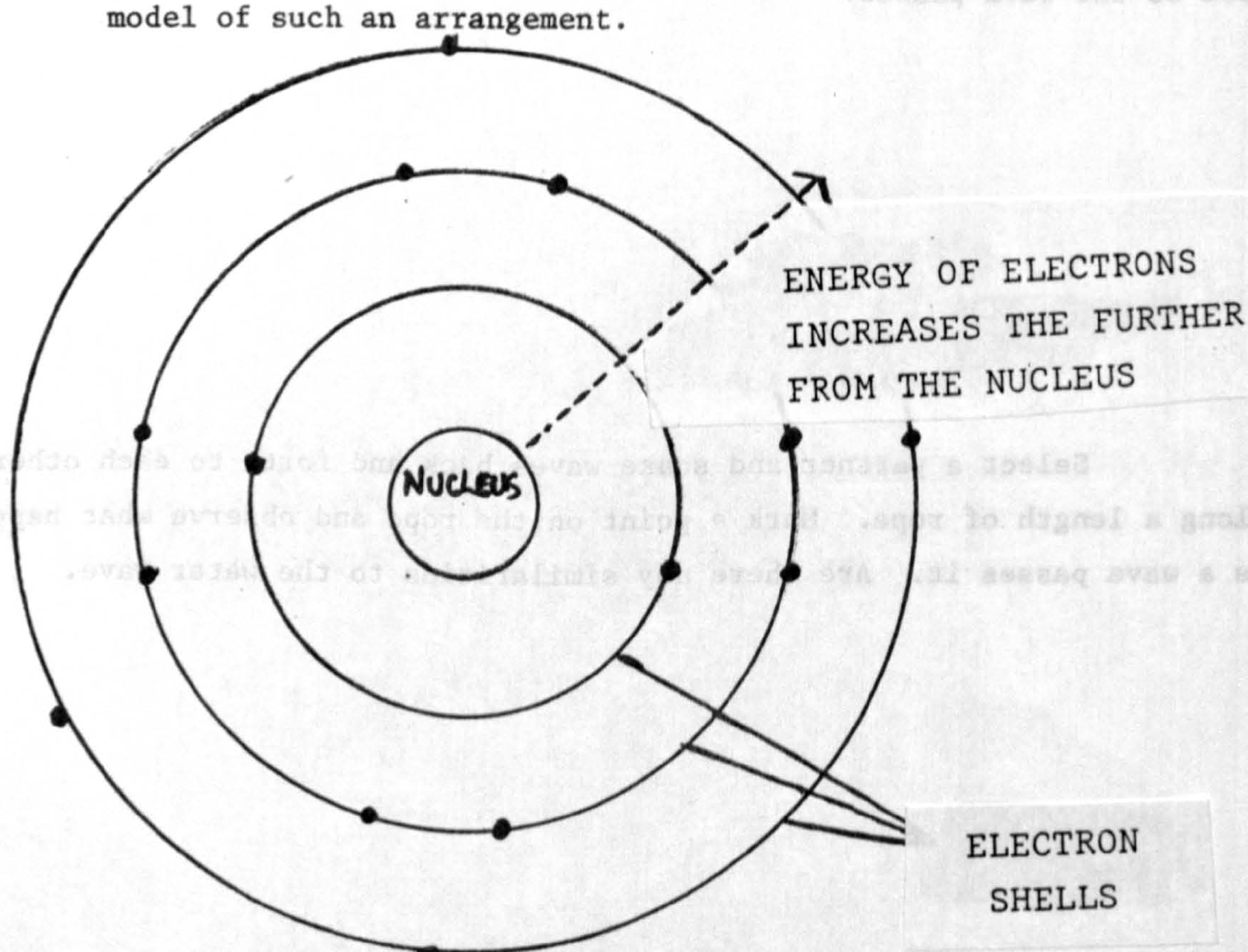
Light - A Wave

Place a small piece of wood on the surface of a pond, or you can use a large pan of water. Generate a small wave by throwing a stone or using some other method of disturbance. What happens to the wood as the wave passes?

Select a partner and shake waves back and forth to each other along a length of rope. Mark a point on the rope and observe what happens as a wave passes it. Are there any similarities to the water wave.

The Atom and Light

How is the energy of light produced? To understand this we have to consider a little more about atoms. Although originally atoms were thought to be small hard spheres, we now know that they are made up of smaller sub-atomic particles. A very simple model of an atom which we can use, pictures the atom as having a heavy nucleus surrounded by smaller particles called electrons, somewhat like planets revolving around the sun. The electrons around any atom are arranged in orbits. The diagram below gives a simplified model of such an arrangement.



Each orbit corresponds to an energy level, the further out from the nucleus the more energy the electrons have. When energy is given to an atom, for example when electrical energy is passed through a gas as in a neon light or if a substance such as fuel burns then the electrons gain energy and move to an orbit further from the nucleus. However, the electrons soon return to a lower level and then release energy. One form in which this energy can be released is as visible light. Some substances give off light energy in which all the waves are the same, while other substances give off light which consists of a mixture of waves.

We have said that light behaves in a manner which makes scientists think that it has a wave nature. Although we will not spend a long time considering the properties of waves the following activity may help illustrate the wave nature of light.

Diffraction

The photo below shows water waves bending as they come through the entrance to Petty Harbour.

Now we can illustrate a similar effect with light. Take a small ball-bearing about 2-3 cm. in diameter and fasten it to a glass plate with a small dab of glue or plasticine. Your teacher will fix a lighted flashlight bulb at one end of the room. Stand at the opposite end of the room with a ball-bearing at arm's length and between the lamp and one eye. Using a magnifying glass examine with this eye the shadow of the bulb. Record your observations. How do you explain what you see?

Your teacher will show you some slides in which you can clearly see the bending of light around objects. It is evidence such as this which makes scientists think light has a wave nature.

Light - A mixture of colours

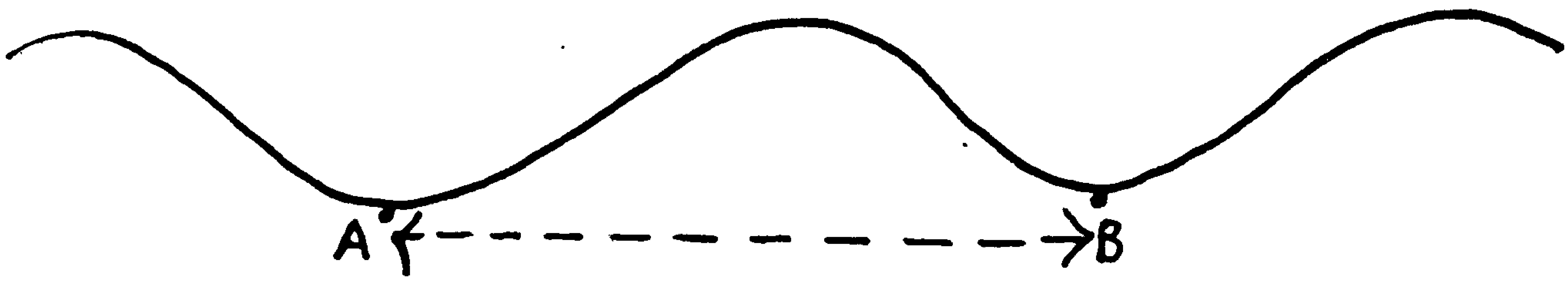
All of you will have seen a rainbow and the wonderful display of colours associated with it. The colours which are seen are the result of light from the sun being sorted into its constituent colours. Other phenomena that we see around us often result in this splitting of white light into colours. Can you think of any other examples of phenomena which result in the rainbow colours?

Look through a prism at different objects. Describe the images that you see.

A prism can be used to separate white light into its constituent colours. Your teacher will demonstrate this for you. Record your observations below. Include a diagram of the apparatus.

What, in fact, do we mean when we say that the prism breaks white light up into its constituent colours? Remember earlier we mentioned that light travelled as a wave, Well not all the waves are necessarily the same. When discussing waves one important characteristic is the length of waves. We can illustrate with the diagram below which represents a wave in a rope?

The distance between any two corresponding points is a wavelength.



A WAVELENGTH

White light is in fact, a mixture of different wavelengths. The prism manages to separate the light so that waves of the same length go in the same direction. The eye perceives these waves of the same length as specific colours. Thus the colours that you see produced by the prism are the result of white light, which is a mixture of different waves, being sorted into groups of waves of the same length.

From the demonstrations you have seen defend the following conclusions

a. White light is composed of many colours.

b. Red light is refracted less than violet light. Other colours are refracted in intermediate amounts between red and violet.

The colours produced by passing white light through a prism are called the colours of the spectrum. However, the colours of the spectrum are in fact only a small part of a larger family of energy waves called the ELECTROMAGNETIC SPECTRUM. The diagram below shows you the whole range of electromagnetic waves. Note what a very small range that our eyes are sensitive to.

Name of group	*Wavelength range*	*Remarks*
low-frequency	from extremely long, down to about 600 meters	Radio waves are seldom used below 10,000 cycles. This group includes weather and some aviation broadcasting among others.
broadcast radio band	from about 600 meters down to about 200 meters	In North America, this band of radio waves has been set aside for commercial AM broadcasting, called the "regular broadcast band."
higher frequency radio waves	from about 200 meters down to about a tenth of a milimeter	In this region are many kinds of broadcasting, including amateur radio, television, FM radio, television microwave relays, and a great deal of experimental work.
infrared rays (sometimes called heat waves	from about a tenth of a millimeter down to about 0.000075 cm	This radiation is given off by very hot objects. It can be detected by your sense of feeling as temperature, but not by your eyes. The radiation is generally converted directly to heat when it strikes something. Often this is called radiant heat.
visible light	from 0.000075 cm down to 0.000040 cm	This is the group of electromagnetic waves to which our eyes happen to be sensitive. Except for this, they are much like the groups above and below them on this chart.
ultraviolet radiation	from 0.000040 down to about 10^{-6} cm	Sometimes called ultraviolet light or black light. This produces visible light when it strikes certain chemicals; it also produces sunburn.
X rays	from about 10^{-8} meters to about 10^{-10} meters	These are the well known X rays used to examine your teeth, to study bones, and to detect flaws in metals and plastics. X rays also have many important scientific uses.
gamma rays	from about 10^{-10} meters down to at least 10^{-13} meters	Gamma rays are like X rays, but their source is different. X rays are usually produced in special X-ray tubes, but gamma rays are usually produced from within the atoms of materials.

Why Grass Appears Green

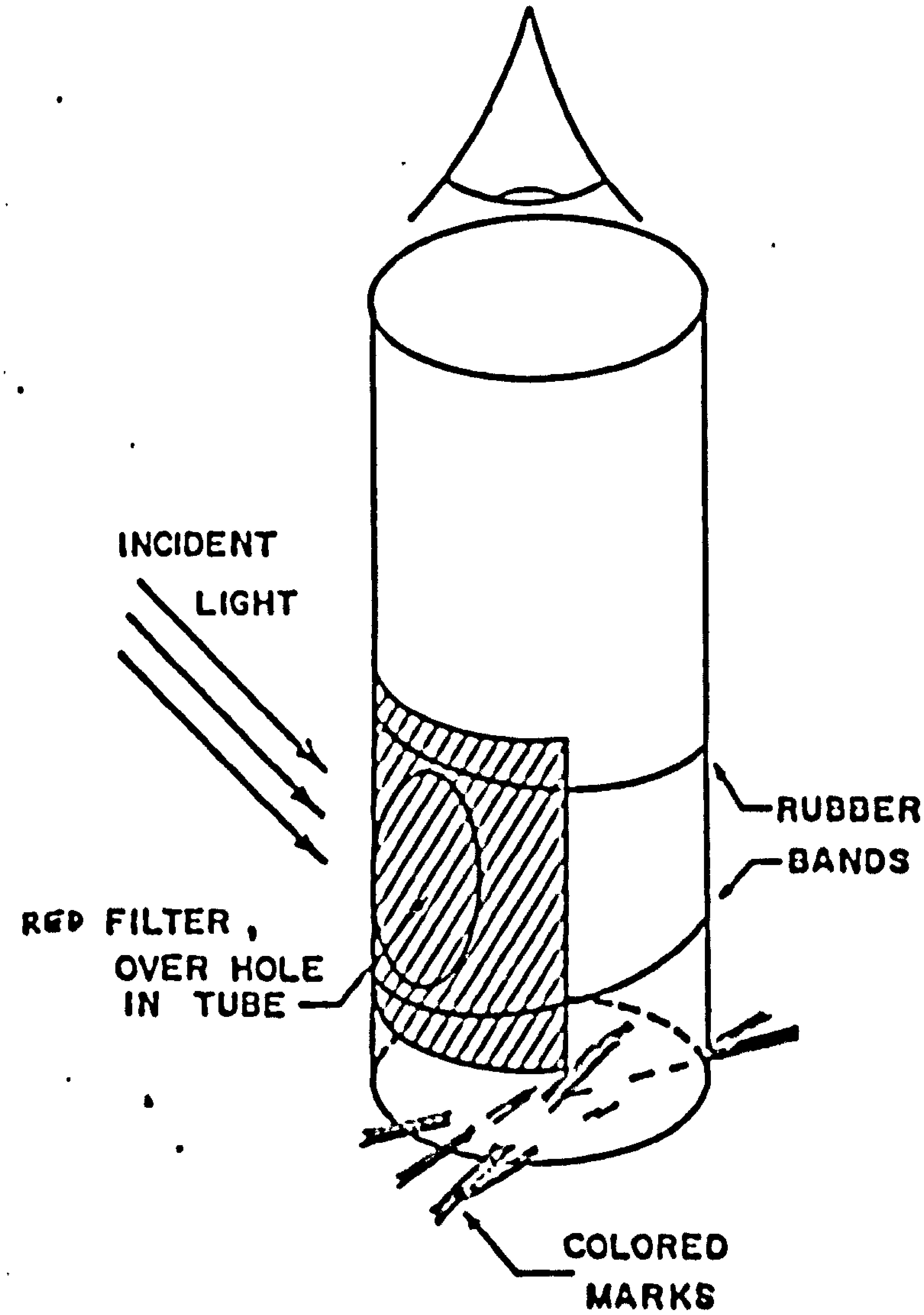
Imagine any colourful scene. It is a bright sunny day. All of the light reaching our eyes (producing the sensation of colour) originates in the white light of the sun. Grass (for example) generates no visible light of its own; if it did it would glow at night. How, then, does the white light from the sun become the various colours in our scene? The coloured objects have taken the sun's white light and have done something with it - something different for each differently coloured object. What is it that they have done?

At one time some people thought that a coloured object added coloured light to the white light. Others thought that the object removed something from the sun's white light, leaving it coloured.

Let's examine these two hypotheses and see whether either is in agreement with our observations. First, as we have already pointed out, green grass produces no light of its own. Therefore it cannot add green light to the sun's white light. Apparently the first hypothesis is incorrect.

Let us consider the second hypothesis. Could coloured objects absorb part of the white light? If they all absorbed the same part, then they would all be the same colour. Therefore if the hypothesis is correct, they must absorb different parts. Could it be that the grass is green because it reflects the green light and absorbs the remainder of the sun's white light? Let us test this hypothesis by performing an experiment.

Make red, blue and black marks on a piece of white paper. Use the red and blue crayons which are supplied for you and a regular black pencil. Using the apparatus pictured below, look at the marks you have made!



Describe the appearance of each mark as viewed through the red filter.

Is the first hypothesis in agreement with your experimental results? The second?

Discuss the evidence.

Can you explain why there is so little difference between the red mark and the white paper when both are viewed through the red filter?

Assignment:

1. Suppose you are wearing dark-green sunglasses as you drive along a street in town. You come to a traffic light in which the lights are side by side. On what basis would you make the decision to drive through this intersection?

2. Why do clothes often appear to be different colours in daylight than in artificial light?

VI. THE FUNCTION OF THE EYE (II)

We are now able, after an examination of additional properties of light, to examine another important function of our eyes, that of colour detection.

The Retina

The human eye is able to detect electromagnetic radiation in what we call the visible portion of the spectrum. This visible portion consists of the colours we call red, orange, yellow, green, blue, indigo and violet. We are also able to see other colours such as brown, pink, silver and grey. In all we can see over 200 colours. But we cannot see infrared, ultraviolet, radio waves and other waves in various parts of the spectrum. We are essentially blind when you consider most of the electromagnetic spectrum. Turn back to the last section and reread the section on the electromagnetic spectrum.

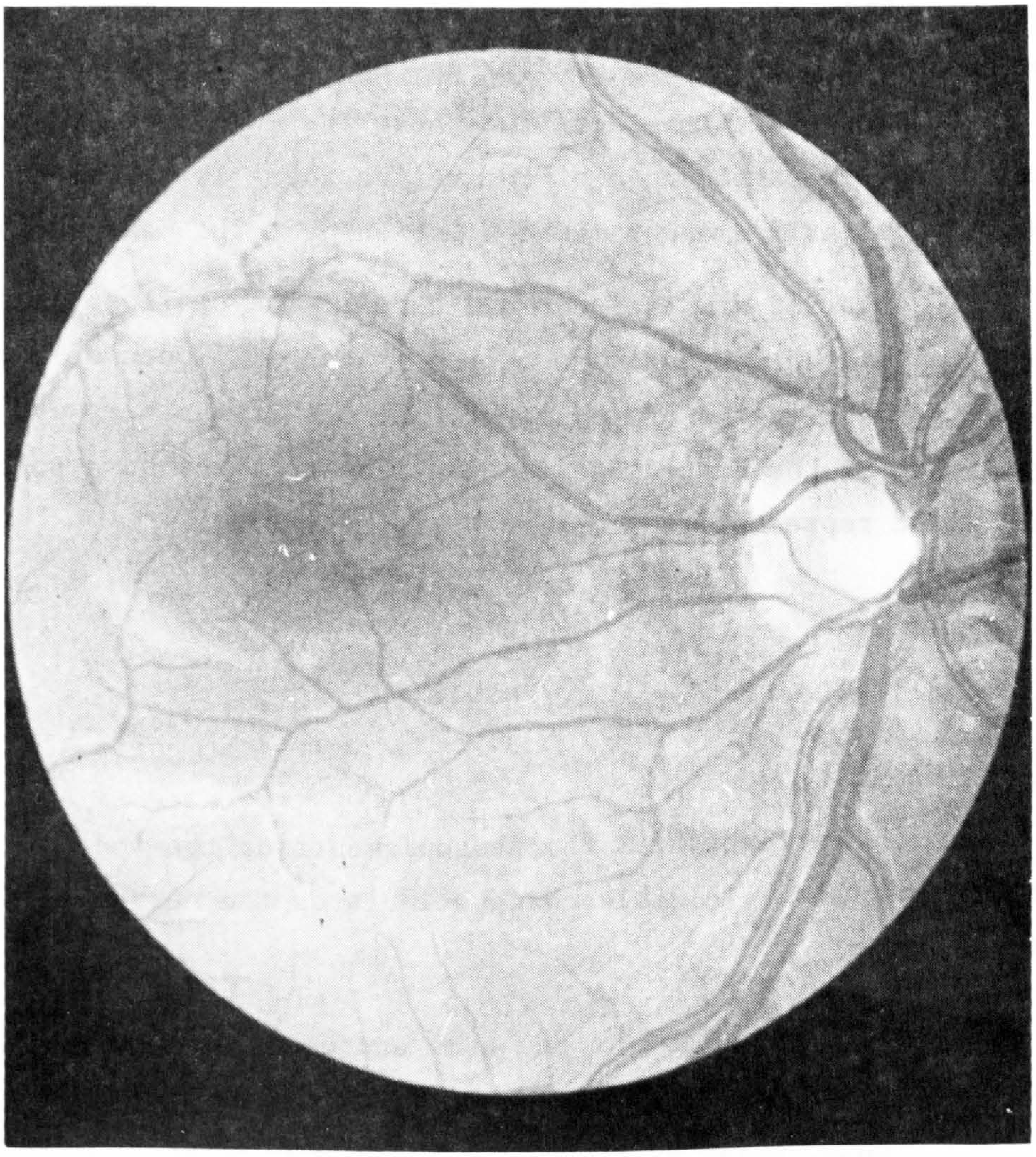
What do you think it would be like to "See" ultraviolet or radio waves? If a being from another planet whose eyes were sensitive to ultraviolet light came to earth, how could he describe to you what he sees?

It seems that other primates such as monkeys and chimpanzees can also see colour. How do you think we can be sure of this?

Also other lower animals such as birds, fish, reptiles, and insects such as bees and dragon-flies have well developed colour vision. There is even some evidence that bees can see ultraviolet.

But interesting enough no mammals other than the primates can see colour. It is hard to imagine the grey world of our pet cats and dogs. This is particularly true when you consider how important colour is to our emotional state. Can you think of an experiment which would prove that your pet dog cannot see colour?

Our ability to detect colour is due to the retina. The retina is a thin sheet of interconnected nerve cells at the back of the eye. A black and white photograph of the retina appears below. In reality the retina is pink with a number of red blood vessels crisscrossing it. The retina is the screen on which the image from the lens is formed.



The retina is in fact an extension of the brain, that is, it is a specialized part of the brain which has budded out and become sensitive to light.

These are two kinds of light-perceptor cells in the retina, the rods and the cones.

The cones give colour vision and work best during daylight. The rods work best in the evening and are sensitive only to shades of grey. There are many more rods near the edge of retina than near the centre. Near the edge of the retina there is no colour vision. Recall your earlier experiment on motion near the edge of the eye.

How big are the rods and cones? The smallest ones are only about one micron across. One micron is one millionth of a meter or about two wavelengths of red light. To put it another way, if the whole population of the United States were made to stand on a postage stamp, they would represent the rods on a single retina.

After-Images

When light hits the photopigments of the rods and cones it "bleaches" them. This bleaching stimulates the nerves that send signals to the brain.

The bleaching of the rods and cones leads to an interesting phenomena known as "after-images".

Have your teacher shine a bright light in front of the class. Stare at the light for 3 - 4 seconds. Now close your eyes tight. What do you "see"? Describe this in the space below.

Now after waiting about 3 - 4 minutes stare at the light again. This time after 3 - 4 seconds do not close your eyes but stare at a white surface such as a wall. What do you see? Describe this in the space below.

Given the following information, see if you can explain your after-image observations.

> For a few seconds after the retina is subjected to a bright light the photochemicals in the rods and cones continue to fire. However, it also takes some time after firing for the photochemicals to return to normal. They in a sense become numb for awhile and the sensitivity of the stimulated part of the retina is reduced.

Color Vision

We all realize how important colour vision is to us. Not only does it play a major part in art but it can also have important effects on our emotional state. Studies have shown that the colour of walls in office buildings can have a definite effect on work output.

What colours do you find restful, relaxing? Compare them to the other class members. What colours are the walls of your classroom? Do you think it would be easier to work if the walls were of a different colour?

Interesting enough the theory of colour vision is not that well developed. It is important for us to realize that in spite of the many advances in science that there are still basic areas about which we do not have a complete understanding.

Although many theories of colour vision have been advanced the one that continues to receive the most attention is that proposed by Young and Helmholtz in the early 1800's.

We found in Section VII, that all the colours of the spectrum can be produced by a combination of red, green and violet. Because of this Young felt that there must be three different types of cones in the retina, one sensitive to red, one to green and one to violet. When the red and green cones are activated we see yellow. When all three cones are activated we see white.

But how do we know that there isn't for example, a special cone sensitive to yellow? When we mix red and green lights the yellow we get is indistinguishable from the yellow we see through a yellow filter.

A more important question is: How is it possible for us to see non-spectral colours such as brown and pink? This is particularly interesting when you consider that both colour photography and colour television are based on the mixing of the three primary colours, red, green and violet. Yet we see brown in colour photographs and on colour television. But when we mix coloured lights by shin ing them on a wall we do not get brown.

Clearly the theory of colour vision is not so clear.

Not long ago a very interesting set of experiments on colour vision were carried out by Edwin Land, inventor of polaroid and the famous Polaroid Land Camera. Basically what Land did was the following:

He took photographic negatives of the same scene, each through different colour filters. For example, one picture was taken with a red filter in front of the camera and another picture was taken with a green filter in front of the camera. He then developed these into slides. If you look at each slide alone through a projector, all you see is a black and white picture. In each slide the shades of grey are different but they are still both black and white slides.

But if you now take each slide and project it through the original filter used in front of the camera and overlap the two slides (using two projectors) <u>all colours</u> in the original scene are visible on the screen.

This phenomena is not easy to explain. Apparently the colour we see depends not only on the frequencies of light but also on whether the patterns are accepted as representing objects. This involves the brain as well as the eye. In thinking about vision we may tend to concentrate too much on the eye and forget the brain.

The importance of the brain will be seen again when we look at illusions in section IX.

<u>Colour Blindness</u>

Some people are colour blind in the sense that they cannot distinguish between what most people call two different colours. The most common type of confusion is between red and green. About 10 out of every 100 boys cannot tell the difference between red and green. Very few girls have this problem.

Colourblindness must be an inherited trait but it is not clear just what type of color cones are missing in the retina of a colour blind person.

Your teacher has a special eye chart which will enable you to tell if you are colorblind. Record the answers for each member of the class. What are the results?

Eyes in other animals

Most living things are sensitive to light. Some very simple organisms only possess sensitive areas of cells which can detect light but cannot form images. However other animals have highly developed organs which enable them to obtain information from their surroundings. Many organisms have eyes which show specific adaptations to their environment, enabling them to obtain food, and to escape their enemies.

The owl has large saucer shaped eyes. What advantage does this give the owl?

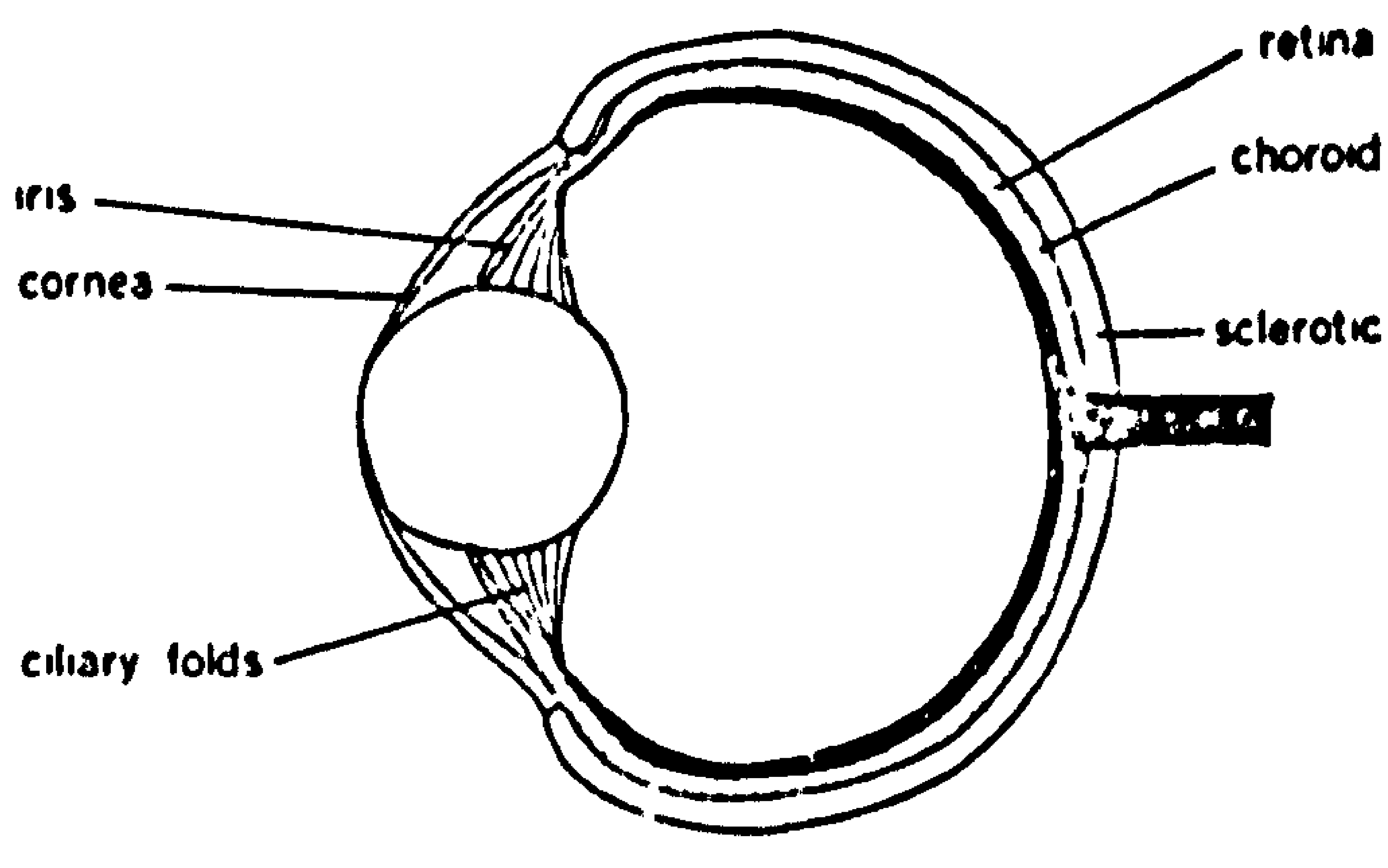
The retina of the owl contains far more rods than the retina of a man. Why do you think this is?

The retina of the owl contains far less cones than does a man. What can you deduce about the vision of the owl?

Examine a cat's eyes, sketch the shape of the pupil. How does the pupil change in bright light and dull light? The cat is an animal which hunts night and day. How do your observations agree with this statement?

Before you read the next section turn back to the earlier section on the eye and refresh your minds as to what accomodation means. We saw that the human eye accomodated by changing the shape of the lens. Most of the bending of the light occurring at the cornea. However, a fish lives in water, and the cornea is very similar to water with respect to its effect on light. Thus very little refraction, or bending of light, takes place at the surface of the cornea. The fish accomodates by changing the shape of the eye as a whole. To focus on a distant object the eyeball is flattened to bring the lens nearer the retina, and the eyeball is bulged outwards so that the lens moves away from the retina in order to focus on a close by object.

Compare the diagram below of a dogfish eye with that of a human. How does it differ?

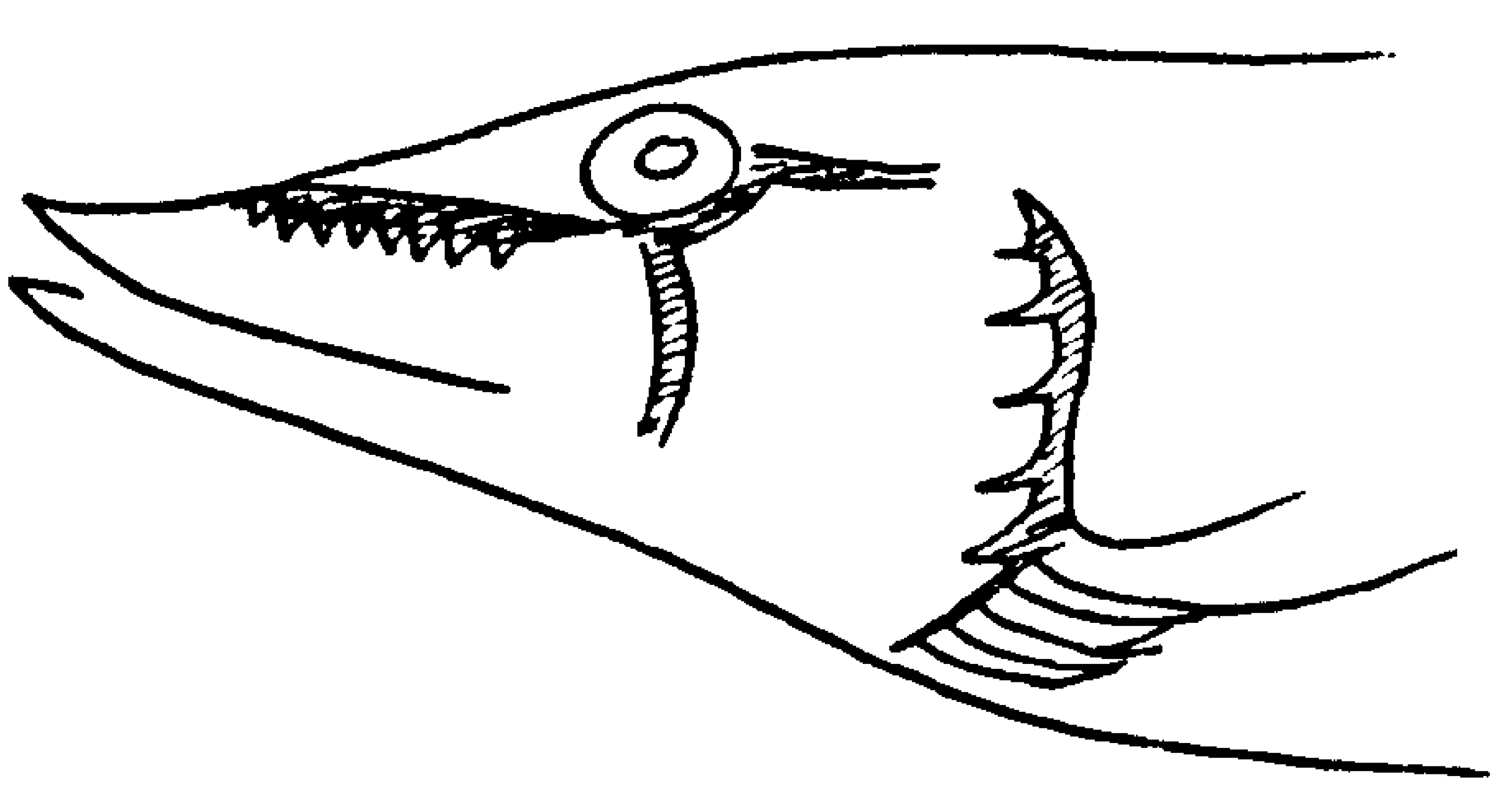


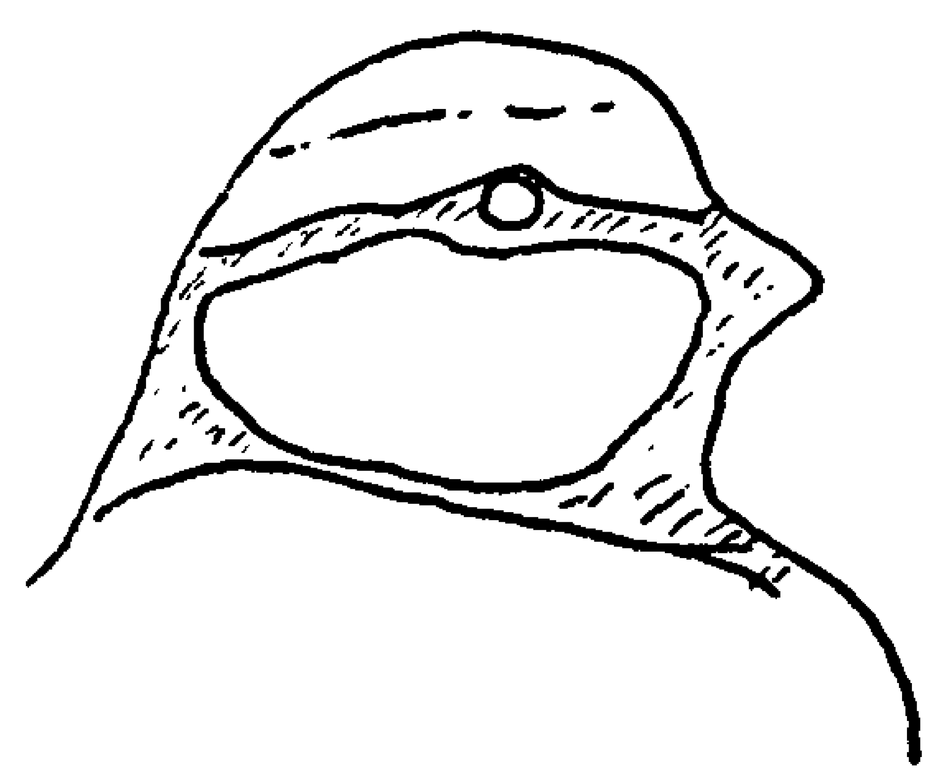
Diagrammatic vertical section of the eye of a dogfish.

The variation in the structure and function of animal eyes is enormous. In each case we can see how the eye is an adaptation to the environment in which the animal lives. Birds, for example, can see over a wide area, virtually all around them. It has been said of an owl that it could walk into a library and read all the book titles at once. Man can only see straight ahead. Many insects have compound eyes which are comprised of a large number of single "eyes" combined together. These eyes cannot focus and cannot form sharp images, however, they can detect the slightest movement. What advantage would that be to a fly?

In many animals the eye is surrounded by lines or patterns. In some cases the markings reduce the glare from the sun. When have you seen humans use a similar principle?

In other cases the lines may serve as sighting lines for catching prey. Similar to the sights on a gun.





We have only considered a few variations in the eyes of animals. The different adaptations of vision that can be found are endless and make an interesting research topic.

Assignment:

1. Moles, bats and shrews, which live in almost total darkness, are almost sightless. What adaptations have these animals developed to replace their lost vision?

2. Cats have a mirror-like lining at the back of the eye. What purpose do you think it serves?

3. Hawks and Eagles have very acute vision. They can spot very small objects at long distances. What special advantage is this to these birds?

Project:

Many insects have compound eyes, which are essentially a bundle of long tubes. You can make a model of a compound eye using soda straws. Cut a large number of soda straws in half and tie them in a bundle. You can use these to produce a blurred image of a lighted candle on a screen. It is best to perform this experiment in a darkened room.

VII. SEEING AND BELIEVING

Is seeing really believing? How often have we made or heard the statement; "I ought to know, I saw it happen". Can we be sure that what we see is what is really happening? If by "see" we mean the images cast on the retinas of our eyes, then we can be reasonably sure that if a group of people look at a given scene or event, that they will all see the same thing. Exceptions would occur for those people who have some eye defect such as colour blindness.

But seeing and interpreting what we see are two very different things. The first involves the eye, the second involves both the eye and the brain. Police who investigate automobile accidents have long known that it is possible for many people to "see" the same accident but for each of them to interpret what they see quite differently. Some people notice things (a bicycle in the road, a driver looking the wrong way) that others do not even though all of them may have seen the same thing.

A popular Canadian television program, EYE BET, illustrates this phenomena very well. In the program, contestants watch a 10-15 second segment of a movie. All contestants "see" the same thing. After the segment is shown they are asked a question about something in the segment such as, "how many times did the man look down at the table?" Some get the answer right, some do not. This "power of observation" requires the use of our brain as well as our eyes.

Your Powers of Observation

Your teacher will conduct a special activity with you. Record your observations below.

Mirages

The previous activity shows us that we have to be careful about statements such as "We know what happened because we were there to see what happened."

There are other ways in which both our eyes and brains can be fooled about what is taking place. One of these is the phenomenon of mirages. Mirages are special types of illusions. In the case of mirages something unusual happens to light before it enters our eyes. In such cases we would expect most people to see and interpret mirages in the same way. A very common mirage is the "appearance" of water ahead of us on a dry road. The short article on the next four pages discusses some interesting miragcs.

MIRAGES-TRICKS OF NATURE

Condensed and Adapted from Popular Science Monthly

H. C. North

Nature played an old trick on Charles Lindbergh, the first man to fly alone across the Atlantic Ocean. Toward the end of the long flight, the tired flier was happy to see green hills and beautiful trees. At last, he thought, he had safely reached Ireland.

"But a few minutes later," Lindbergh said, "this false land disappeared. I found before me the long stretch of the silent sea." When the vision had appeared, Lindbergh was 200 miles from the coast of Ireland!

Fliers have often reported mysterious, shadowy airplanes flying near them. "When my plane comes out of the clouds, with the sun behind me," one pilot said, "I have noticed a second plane 30 or 40 yards ahead of me. Though I know it is my plane's shadow, it always surprises me. The shadow looks exactly like my plane. Often it is surrounded by a circle of rainbow colors."

On mountain tops, travelers may see their own shadows as "ghosts," when sun and mist appear at the same time. On the thick mist, the sun casts a huge shadow of the traveler. Colored circles, or halos, may be around the head of this ghost.

Even an experienced traveler may be fooled by such strange images, called mirages. In 1906 Robert E. Peary, the famous explorer, thought a mirage was a new land in the Arctic. He even gave is a name - Crocker Land! Nine years later, other explorers found that "the faint white summits of a distant land" described by Peary were a mirage.

A mirage is not imaginary, though your imagination may play a part in what you think you see. It is a real experience, caused by unusual conditions in the air.

Light rays are bent when they pass through layers of different thickness or density. When you thrust a straight stick halfway into water, the part below the surface appears to be bent sharply upward. The light rays from the lower part have passed from water to air before reaching your eye. Because water and air are of different densities, these rays have been bent from their usual straight paths. The part of the stick below water appears to be removed from its real position.

Cool air, denser than warm air, acts like the water in the case of the stick. Rays of light are bent in passing from one layer of air to another. So, whenever air layers are of widely different temperatures, mirages may be seen.

On the desert, for example, the hot sand causes a layer of very hot air. Above, the air is usually cooler. The traveler may see what looks like a reflection of trees in a lake. The image is out of place because the hot air bends the light that brings the image to his eyes. The "lake" is sky.

An explorer in northern Canada suddenly saw a camp pitched on top of a mountain, above the clouds. The camp was upside down! Examining it with his telescope, he noticed several dogs around it. After half an hour's travel on flat ground, he found an Eskimo camp. It was the very one he had seen upside down in the air.

In the arctic seas, three ships may sometimes be seen where there is really only one. The first is the real ship. Above it, upside down, is the first reflection. Above that is another reflection, right side up. When warm air passes over frozen seas, it becomes sandwiched between two layers of cold air. So, a double mirage may be seen.

When a layer of warm air rises to great height, the most striking of all mirages-a "loom"-may appear. In one of these looms, off the New Jersey coast, sand dunes 13 miles away were clearly seen in the sky. In Arizona, a loom showed the Grand Canyon in the air. In Wisconsin, Milwaukee appeared above Lake Michigan.

In a mirage sometimes seen off the coast of Italy, castles appear in the sky, with towers reaching dizzy heights. This beautiful mirage is simply a reflection of buildings on another shore!

FIND OUT FOR YOURSELF

Watch for Mirages

Be on the lookout for mirages. One common kind is the water-like shine you often see ahead of you on a highway in summer. Note the conditons (temperature, humidity, location) under which you see any mirages. Try to explain what you see.

When our perception goes wrong we can have experiences that give rise to what are called illusions. It is with illusions that we can recognize most clearly that the brain has a role in perception. At the same time one of the least developed areas in the study of vision is the area that attempts to explain why we see certain illusions. Many theories have been advanced to explain illusions and many of these have been disproved. This is definitely a frontier field in psychology and biology and we can look forward to may advances in the years to come.

Let us first consider an illusion that most of us have experienced. When we look at the full moon on the horizon it appears large and orange but about six hours later when it is overhead the same moon appears white and much smaller. The moon does in fact change colour, as a result of atmospheric dispersion, but as photographs of the moon show, the size of the moon does not change. Photographs of the moon on the horizon and overhead show the same size image. This means that the apparent change in size of the moon must be an illusion. Our retinas receive the same images but our brain interprets them differently.

On the next two pages is a reprint of an article, The Moon Illusion taken from the newsletter Physics Teaching Today distributed to all physics teachers in Newfoundland. It will help you understand some of the problems with this fascinating illusion.

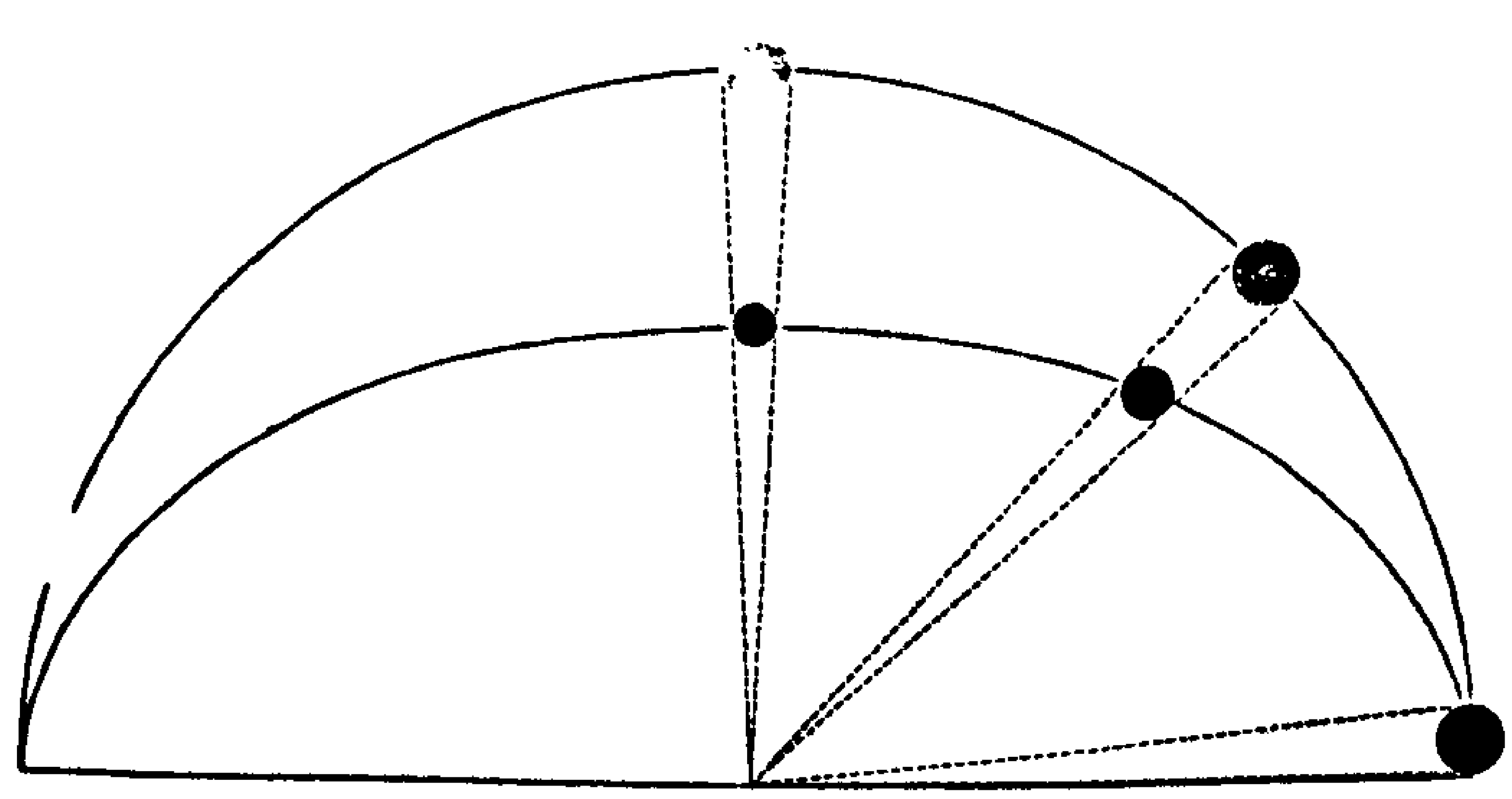
Dr. Richard Reis

Once a month on a clear Newfoundland night a most unusual phenomena presents itself. As the full harvest moon rises in the east it appears as a large redish-orange disk, but by the time it has reached the zenith six hours later it appears much smaller and has changed from redish-orange to white. This apparent change in size and color with elevation (which can also be observed with the sun) has been discussed since the time of the famous Greek astronomer, Ptolemy.

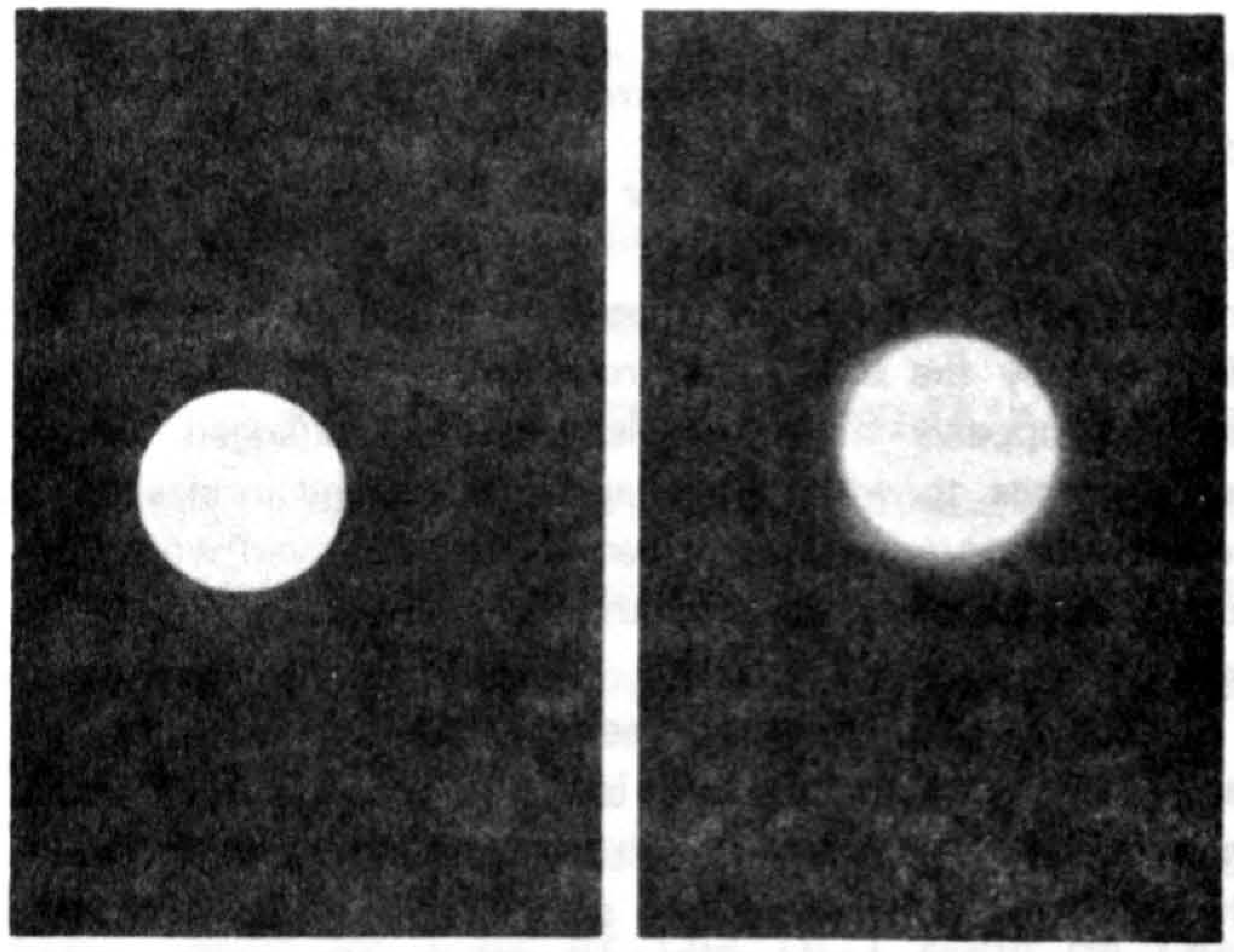
Many people seem to feel that the appearance of a larger moon on the horizon is due to the diffraction of moon light as it passes through the denser atmosphere near the horizon. Diffraction has something to do with the redish-orange color observed, but it has nothing to do with the apparent change in size. This can be seen from an examination of the two photographs in the next column. The photograph on the left was taken with the moon on the horizon and the one on the right was taken six hours later when the moon was directly overhead. The sizes of the images are the same. This means that the apparent change in size is a psychological and not a physical phenomena.

Serious scientific investigation of this "moon illusion" began about 25 years ago and a look at the investigations since that time reveals some interesting features of experimental science as well as some interesting connections between physics and psychology.

Edwin Boring was the first to investigate the illusion experimentally by having subjects compare the size of disks projected at different elevations on a planetarium dome.[1]



Effect of Apparent Distance



Left: Moon on Horizon; Right: Moon at Zenith

Boring came to the rather startling conclusion that the illusion was due to the change in angle of the observers' eyeballs in the sockets of his head! When an observer looked straight ahead at a moon on the horizon his eyeballs were in one position and when he looked at the moon overhead they had rotated to a different position. According to Boring the illusion would disappear if a person were to bend over and look at the horizon moon through his legs.

Many scientists questioned both Boring's experimental methods and his conclusions. In 1965 Kaufman and Rock reported the results of a more elaborate set of new experiments using artificial disks presented in front of the viewer by means of mirrors.[2] They rejected Boring's conclusions and hypothesized that the moon appears larger on the horizon because the sky at the horizon appears **farther** away. This can be understood by examining the diagram at the left. The true positions of the moon are along the upper curve; its apparent position, if the horizon seems more distant than the zenith, would be along the lower curve. The perceived size of the moon would accordingly vary as shown by the darker disks. Convincing as this argument appears, Kaufman and Rock are really explaining one illusion (size of the moon) in terms of another (apparent distance).

The Moon Illusion Continued

Since 1965 there have been many articles on the moon illusion appearing in scientific journals. The most detailed study was completed in 1971 by Frank Restle.[3] Restle accepts the experimental results of Kaufman and Rock but does not accept their apparent distance hypothesis. He advances his own theory based on relative size which not only accounts for previous experimental results but also explains some of the experimental findings which cannot be accounted for by the apparent distance theory. Restle argues that the apparent size of the moon depends on the size of the visual field surrounding the moon. Near the horizon this field is rather small because the distance from the moon to the horizon is small. When the moon is overhead it is in a large empty visual field. This is similar to drawing a line surrounded by a rectangular box. As the box is made larger the preceived length of the line decreases. Restle has even gone so far as to develop a formula by which each observer can predict the magnitude of the illusion he will see.

In spite of all the investigations to date there still remain unanswered questions about the illusion. For example, it would be interesting to know if babies or small children see the illusion, or why some people never seem to preceive a change in size. Would a formerly blind adult who has just been given his sight be able to see the illusion? There is certainly room for further investigations in this area, some of which could be done by imaginative high school students.

REFERENCES

1. Boring, Edwin G., ***The Moon Illusion,*** **American Journal of Physics, April 1943, pp. 55-60.**
2. Kaufman, Lloyd and Rock, Irving, ***The Moon Illusion,*** **Scientific American, July 1962, pp. 1-10.**
3. Restle, Frank, ***The Moon Illusion Explained on the Basis of Relative Size,*** **Science, vol. 167, 1969, pp. 1092.**

Let us now take a look at some interesting illusions that can be seen in printed form. Copies of these illusions, taken from a kit produced by Edmund Scientific Co., appear on the following pages. It is important to realize in the discussion that follows that there is still a great deal that we do not know about these illusions.

1. Hatched Line Illusions.

The illusions A, B and C, make use of lines drawn at an angle to the vertical to make the two vertical lines appear to converge or diverge. In fact in all three drawings the vertical lines are parallel. Check this for yourself with a ruler.

2. Crossed-Bar Illusions.

Figure D shows an example of the crossed-bar illusion. The visual question is whether the left hand line is a continuation of the upper or lower line on the right. Make a guess and then check your result with a ruler.

There are differing, contradictory theories explaining this illusion, but clearly it operates strongly for most people.

3. Perception Illusions.

The illusion in Figure E depends on the conditioning most of us received in learning to read words. We look for dark printing on a white background and disregard the empty spaces surrounding the printed pattern.

The dark masses are perceived as irregularly shaped globs with no perceptual significance. However, when we read the spaces surrounding the masses a word appears. This same illusion appears on the cover for this module.

4. Irradiation Illusions.

Many optical illusions depend on the way we perceive contrasts in brightness. This affects the apparent size of things. Bright areas appear larger than dark areas. In Figure F the distance <u>between</u> the black balls is exactly equal to the diameter of the balls.

In figure G the distance between the tips of the star and diamonds is exactly equal to the distance across the points of the star or diamonds.

Check these for yourself with a ruler.

5. Convergence-Divergence Illusions

The two lines in Figure H are the same length. Very complex explanations have been developed to explain this illusion. The most common is that the eyes are led inward by the converging lines and outward by the diverging lines.

The two patterns in Figure I are the same shape and size. Check this for yourself by tilting the figure at 90^{o}.

6. Oscillating Figure Illusions.

Oscillating figure illusions occur because our attention is concentrated first on a dark portion and then on a light portion. Do you see the two patterns in Figure J?

7. Diagonal Illusions.

In Figure K the diagonal line AX equals the diagonal line AY. Our mind tells us that the diagonal of the larger parallelogram must be larger than the diagonal of the smaller one. We disregard the factor of assymetry.

8. Impossible Object Illusions.

Perhaps the most interesting illusions are the so called "impossible object illusions". A few of these are shown in Figures L, M and N. Most of these illusions are based on the deliberate distortions of the commonly accepted rules of perspective. If we look at one portion of the pattern at a time we are "ok" but if we look at the whole pattern we receive contradictory information and hence the object as a whole appears impossible. This can be extremely frustrating.

The impossible triangle in Figure L appears to be in all three planes - length, width and depth at the same time, an impossibility.

The magic stairs in Figure M is similar to the one appearing on the cover for this module.

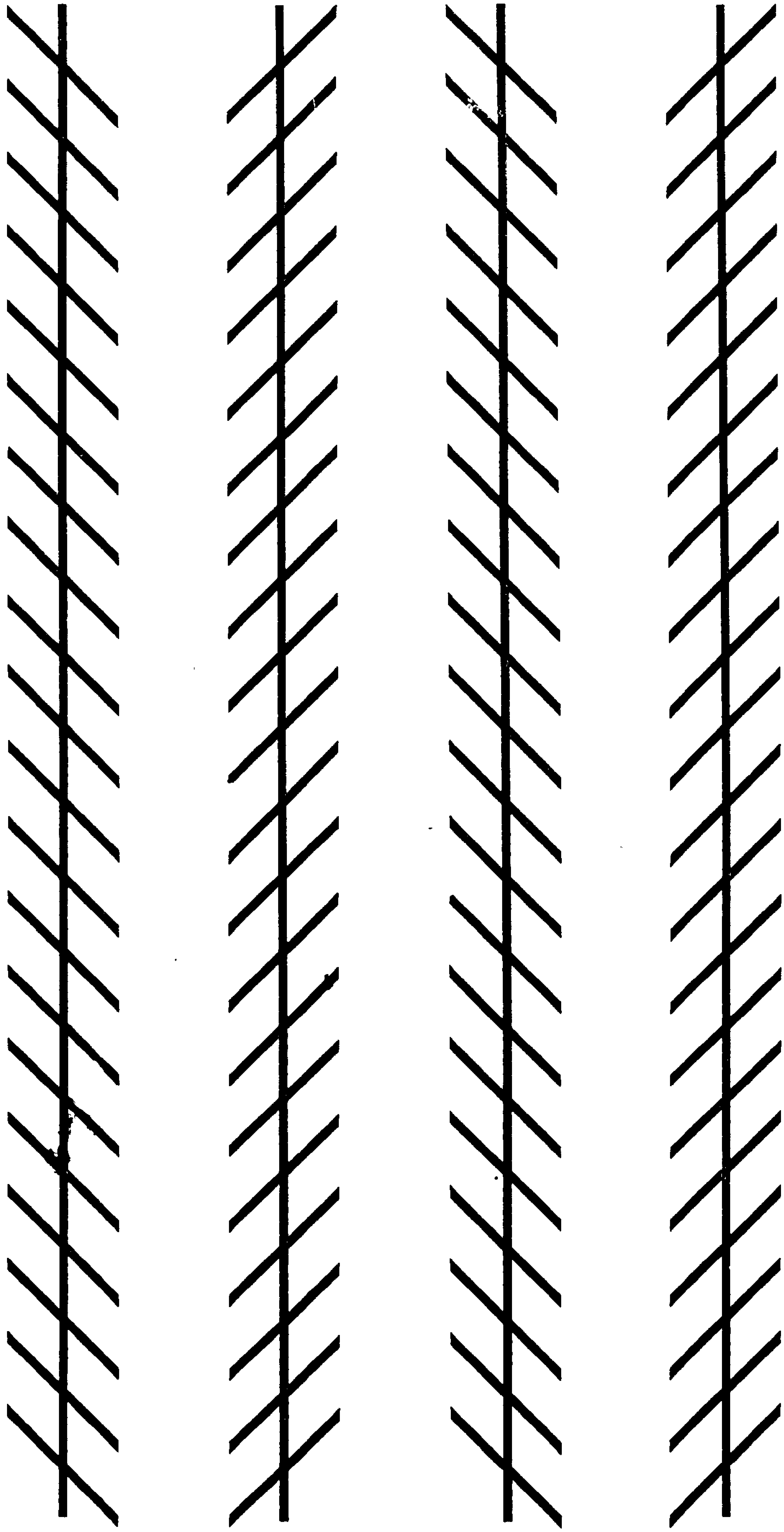
In Figure N we see the most dramatic illustration of an impossible object based on improper use of projection.

Do all of us see the same illusions? Apparently not to the same extent. Some of you saw the word "fly" in Figure E much faster than did others. Our ability to experience illusions must have to do with our past experiences, again indicating the importance of the brain in vision.

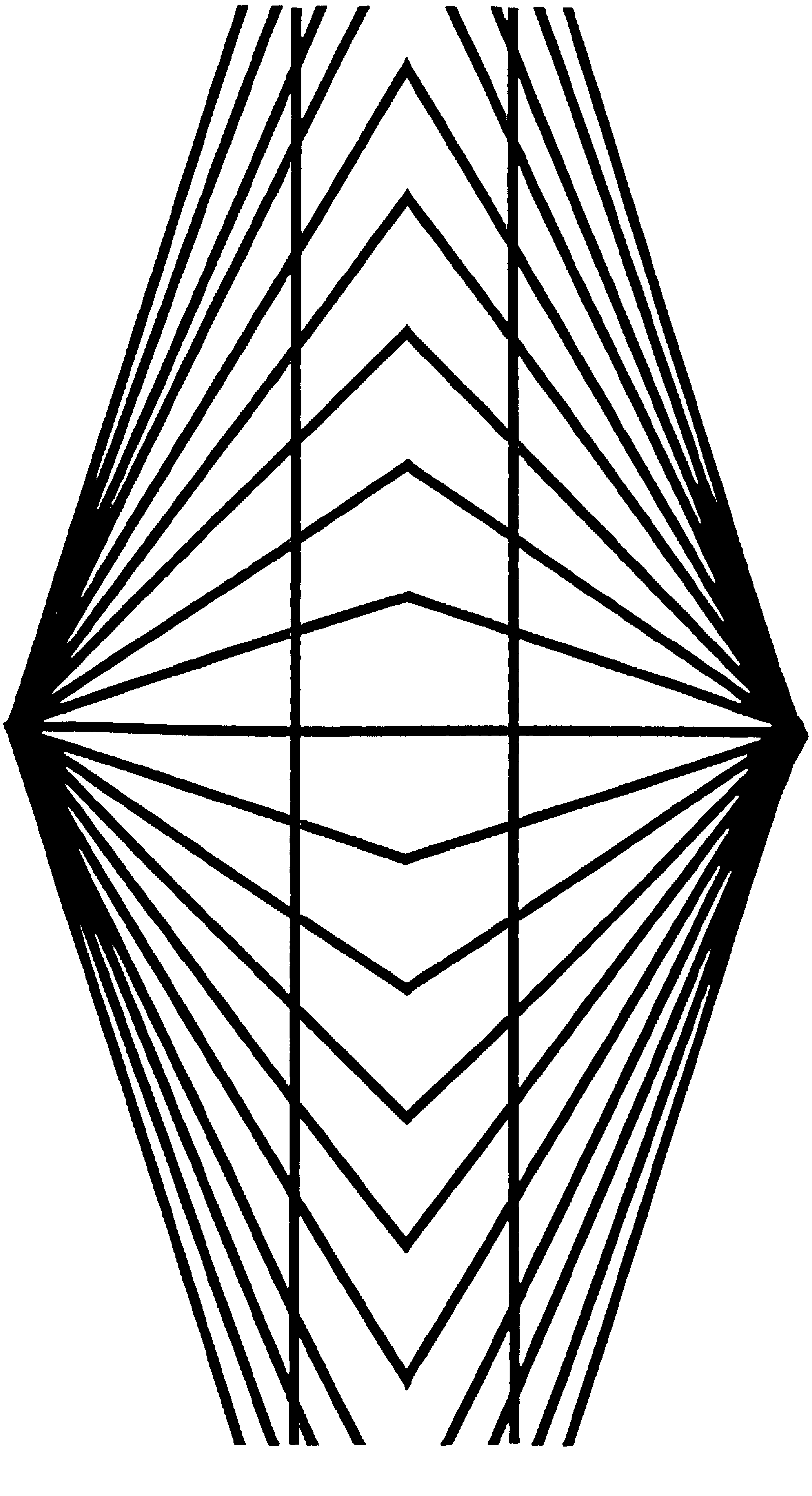
Gregory in his book, Eye and Brain, reports on some interesting experiments conducted with the Zulus. Those of us in the Western World live in an environment rich with straight lines, squares, rectangles and boxes. The culture of the Zulus is essentially a circular culture. Their huts are round, they plow their land in curved furrows and few of their possessions have corners or straight lines.

How do they perceive the illusions you have just looked at? According to Gregory the Zulus do not suffer any of the normal illusions except, to a small degree, the arrow illusion. This is further indication of how important our background is in vision and again shows us that seeing is not always believing.

A



ZÖLLNER'S ILLUSION



WUNDT'S VARIATION OF ZOLLNER'S ILLUSION

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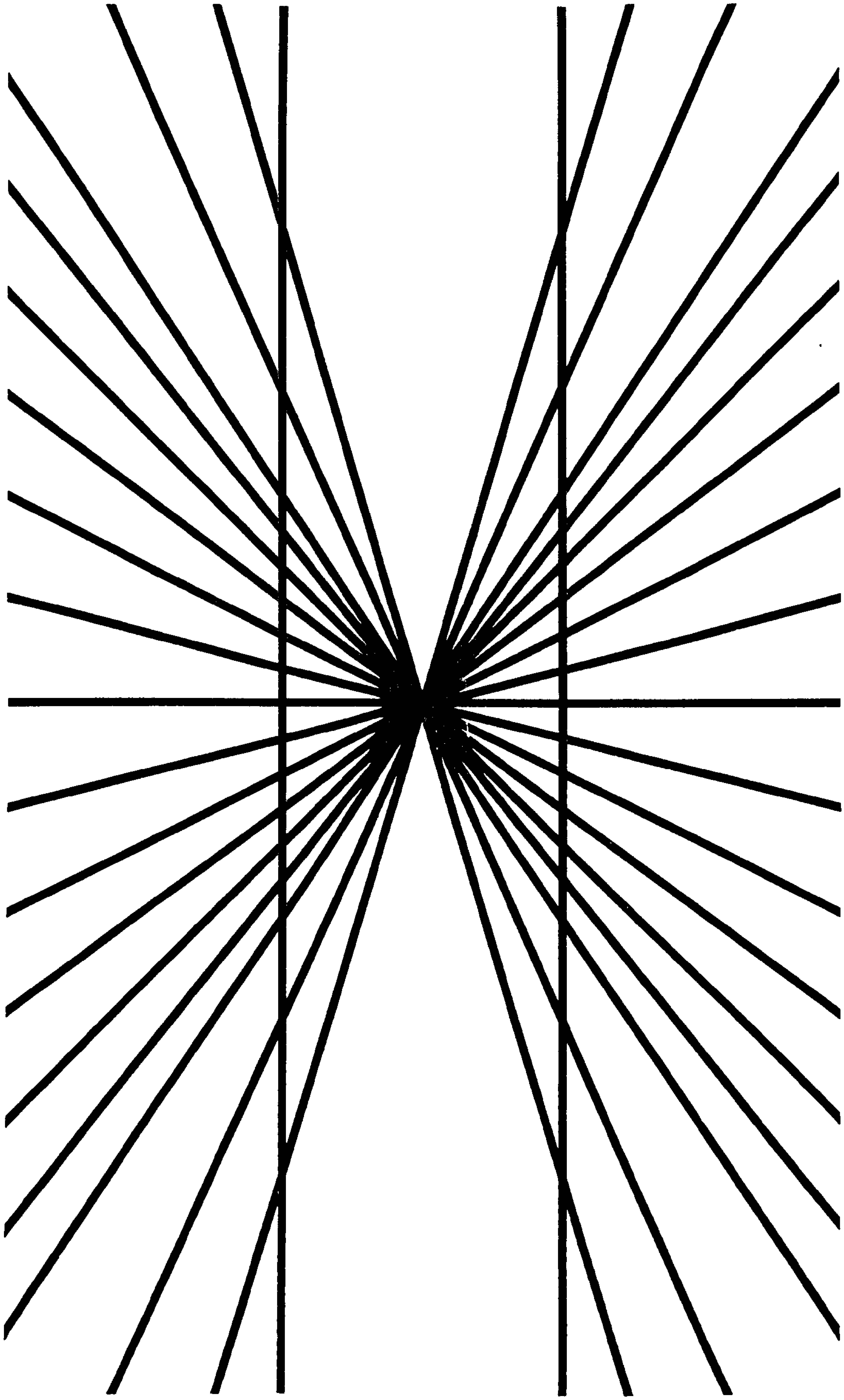

HERING'S ILLUSION OF DIRECTION

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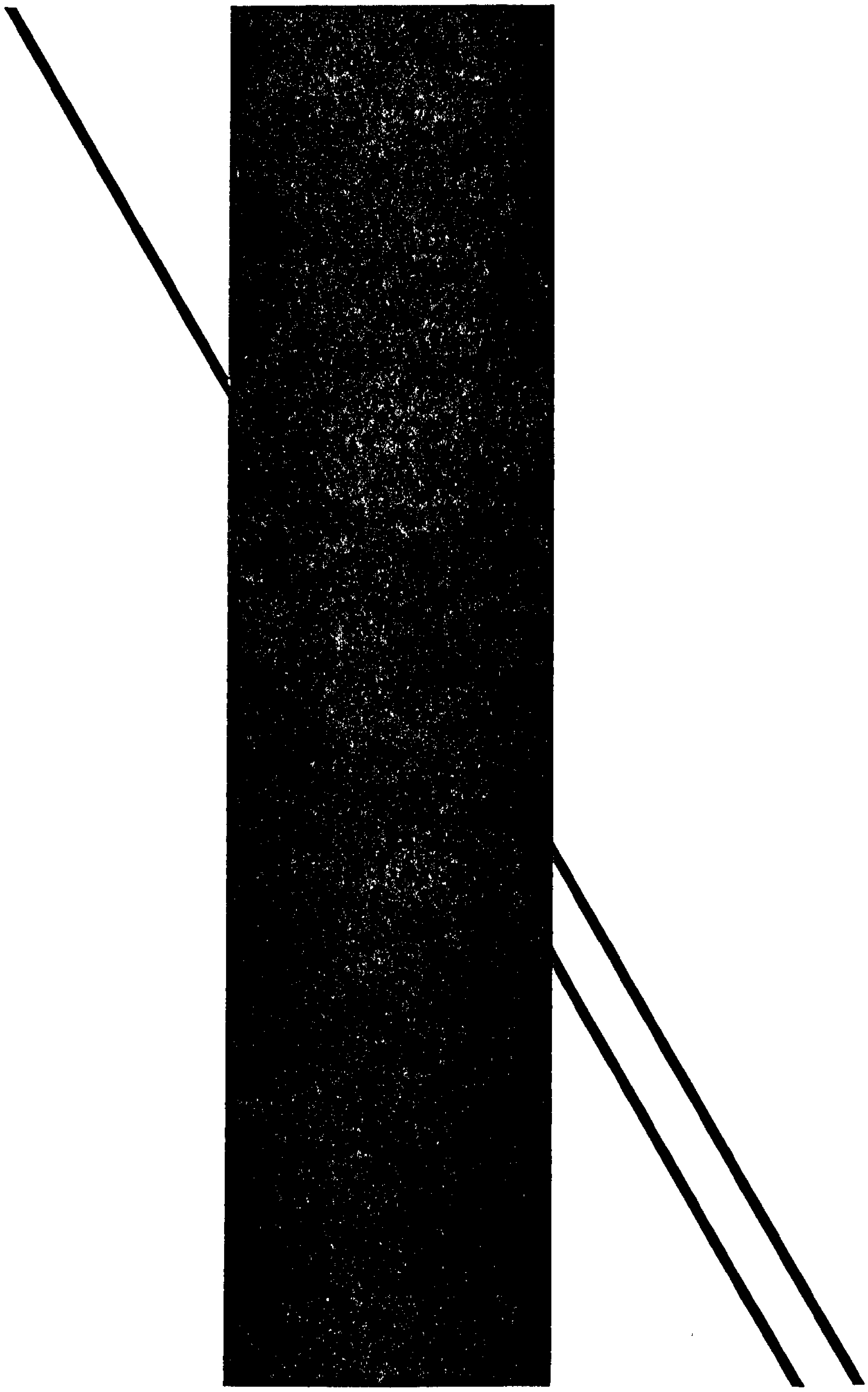

POGGENDORFF'S ILLUSION

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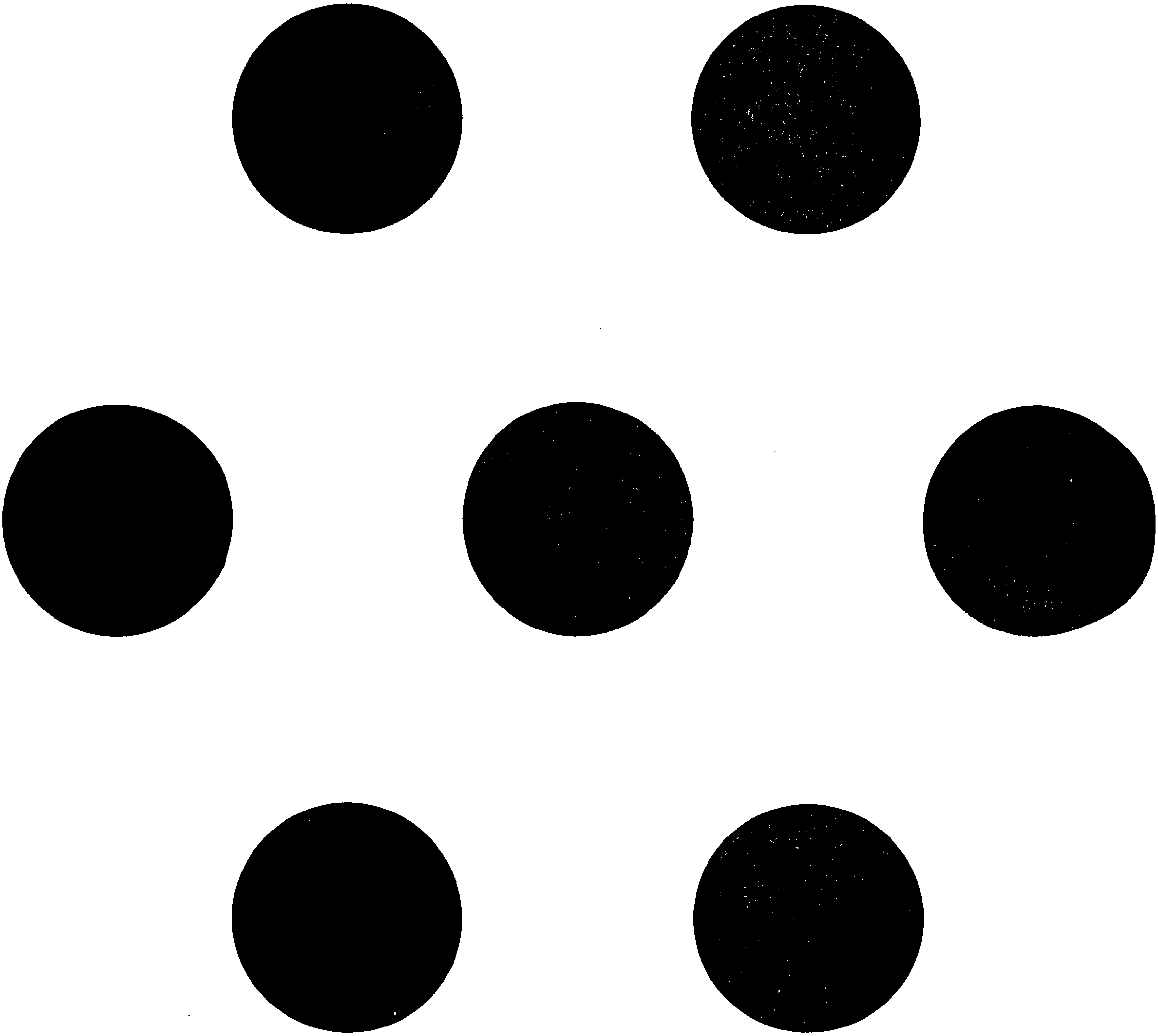
A PERCEPTION ILLUSION



IRRADIATION ILLUSION

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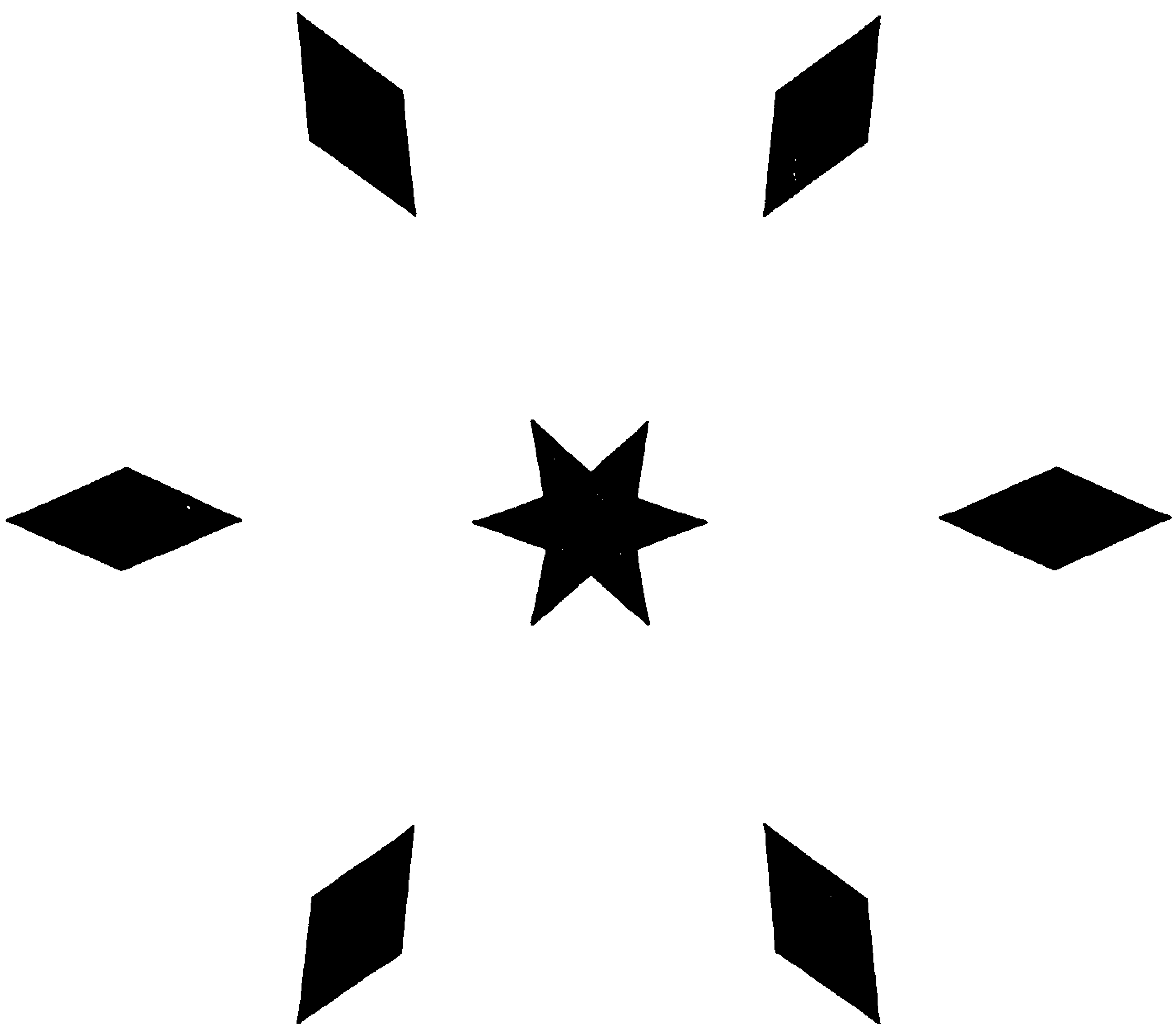

THE STAR ILLUSION

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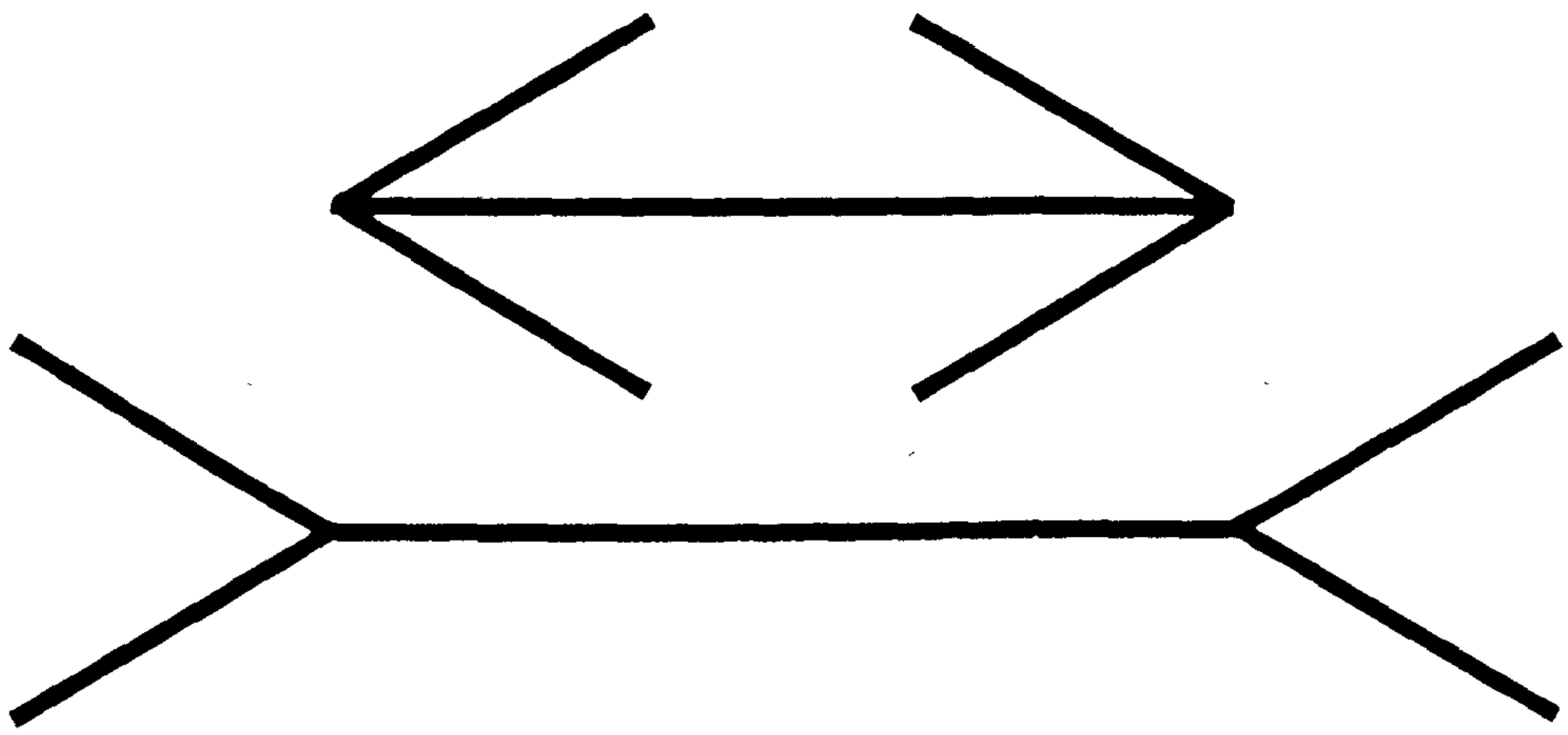

MÜLLER - LYER ILLUSION

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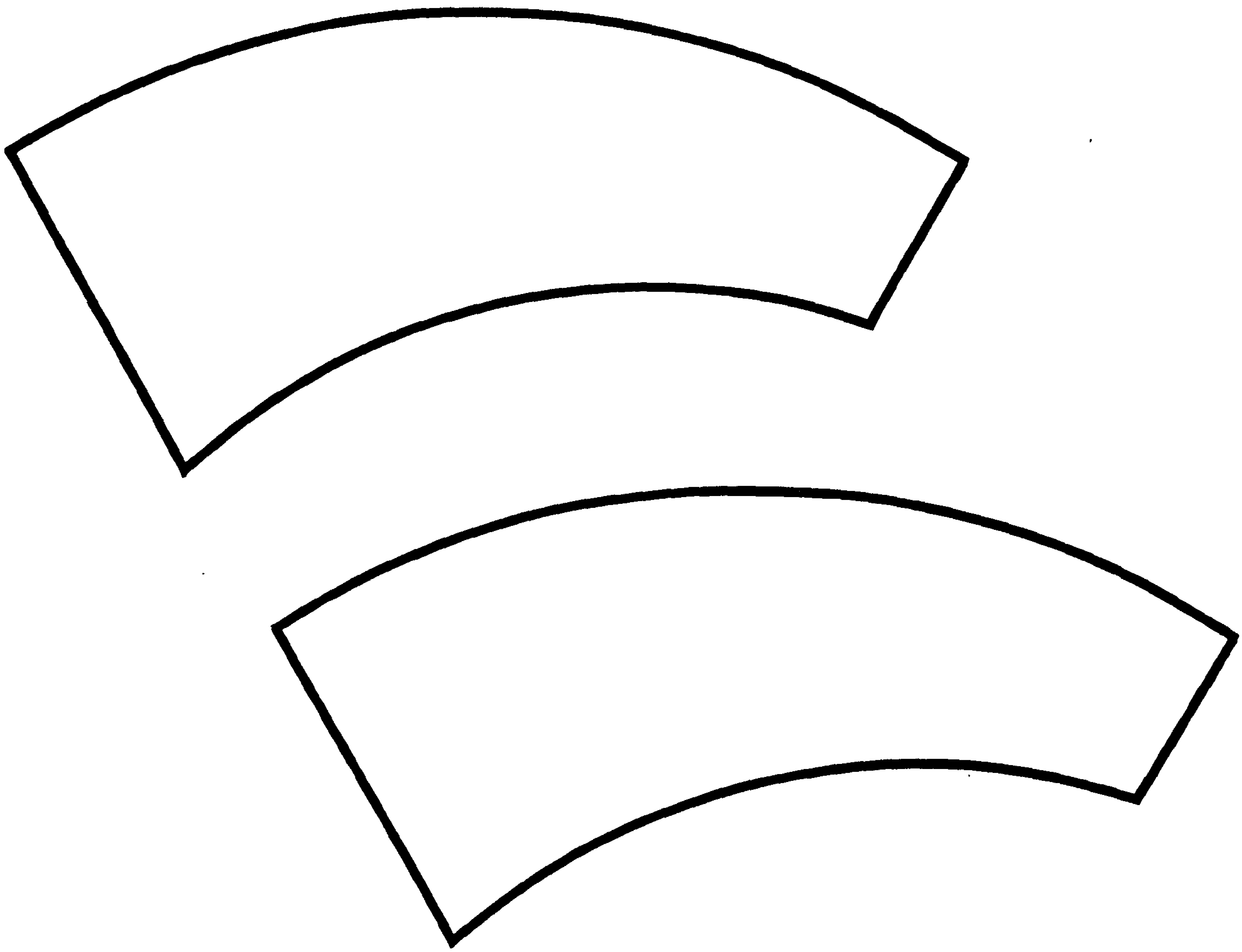

WUNDT'S AREA ILLUSION

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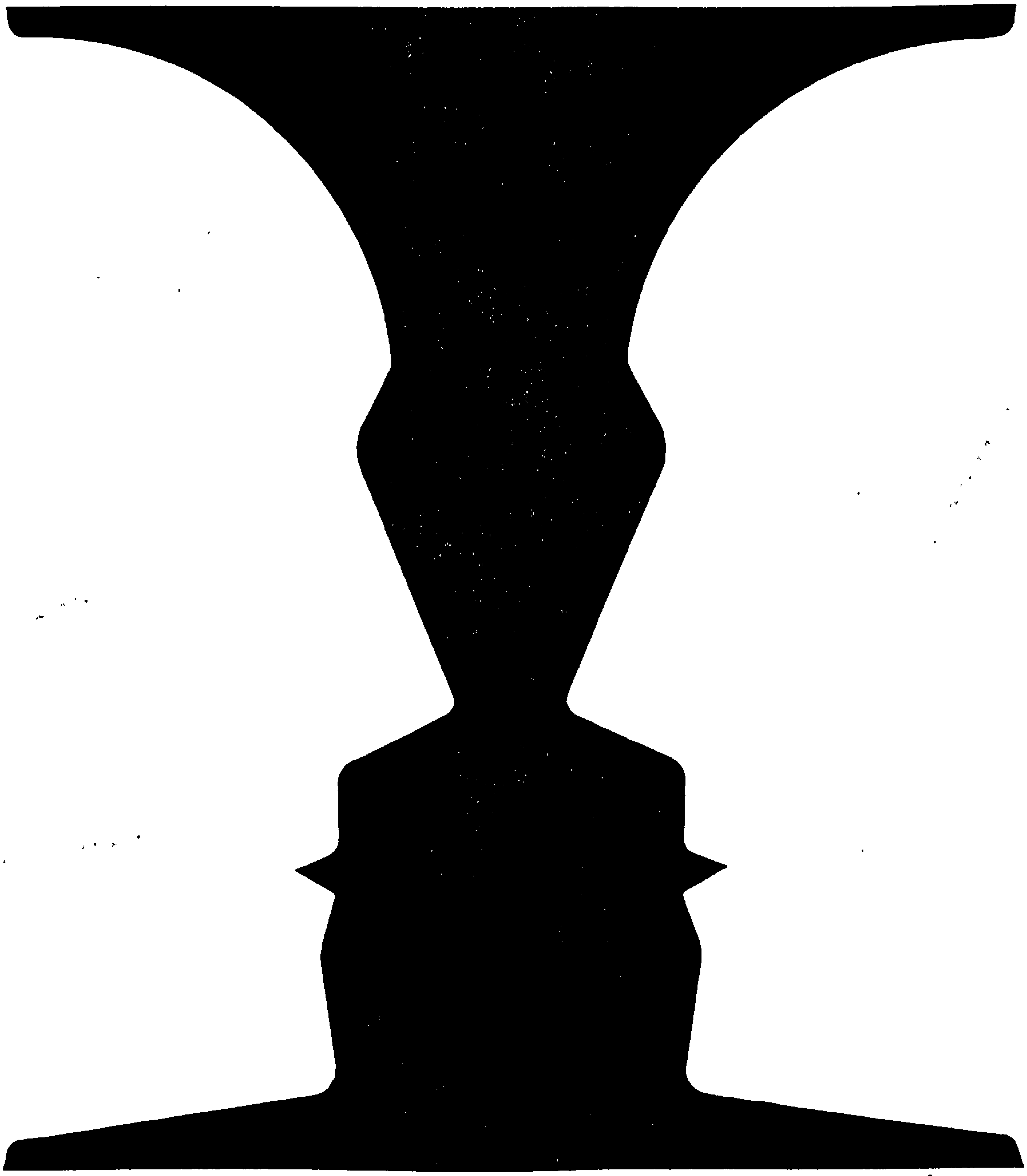
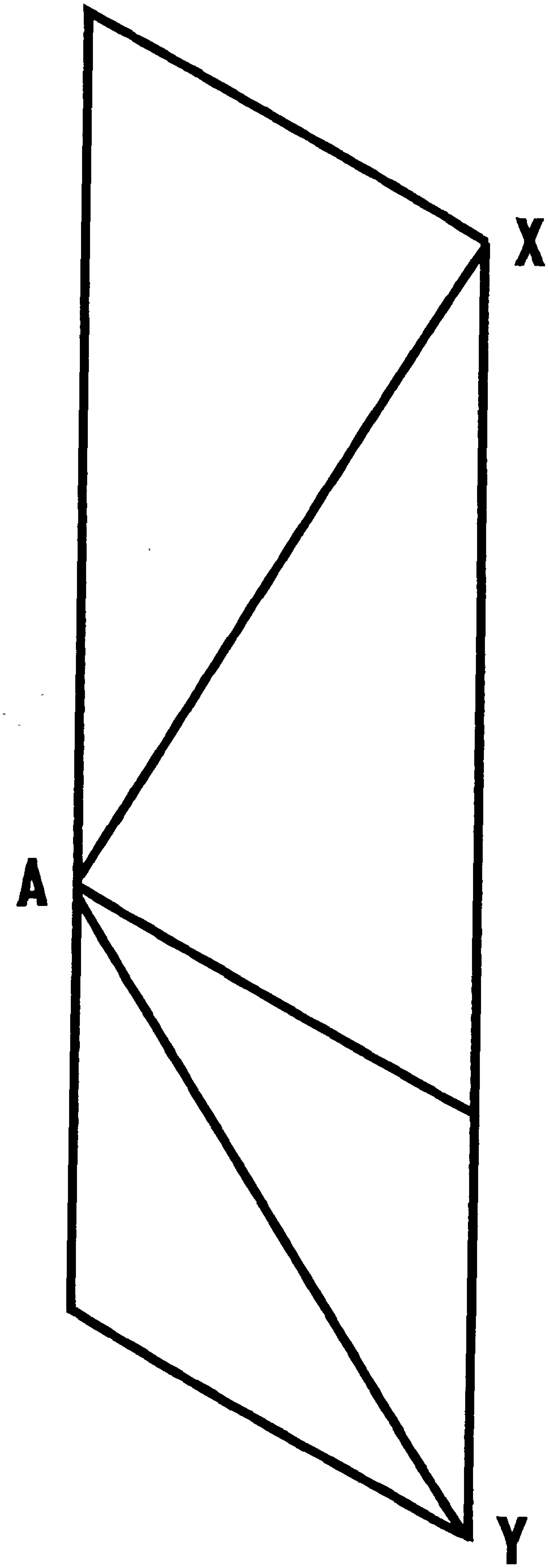
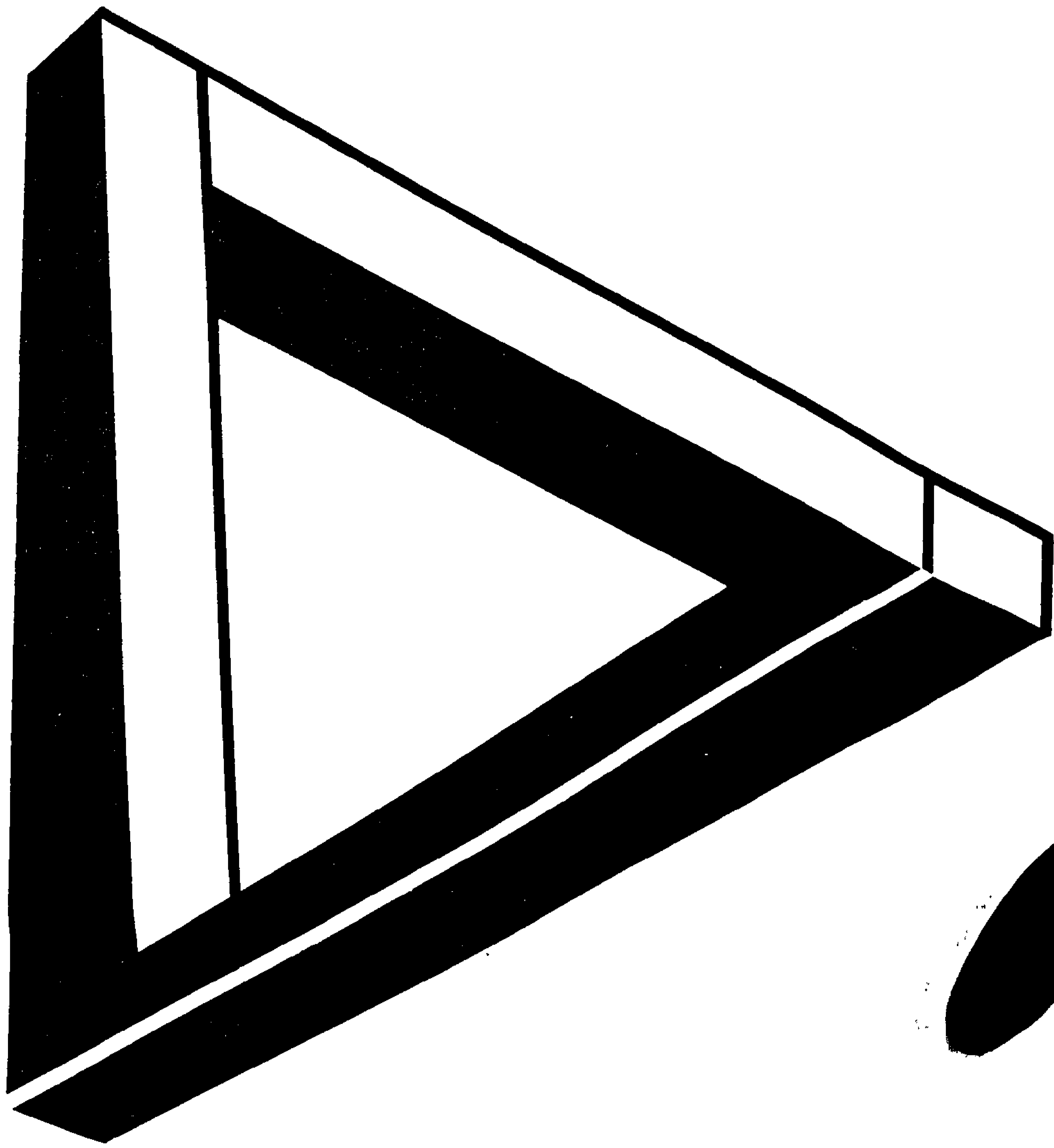


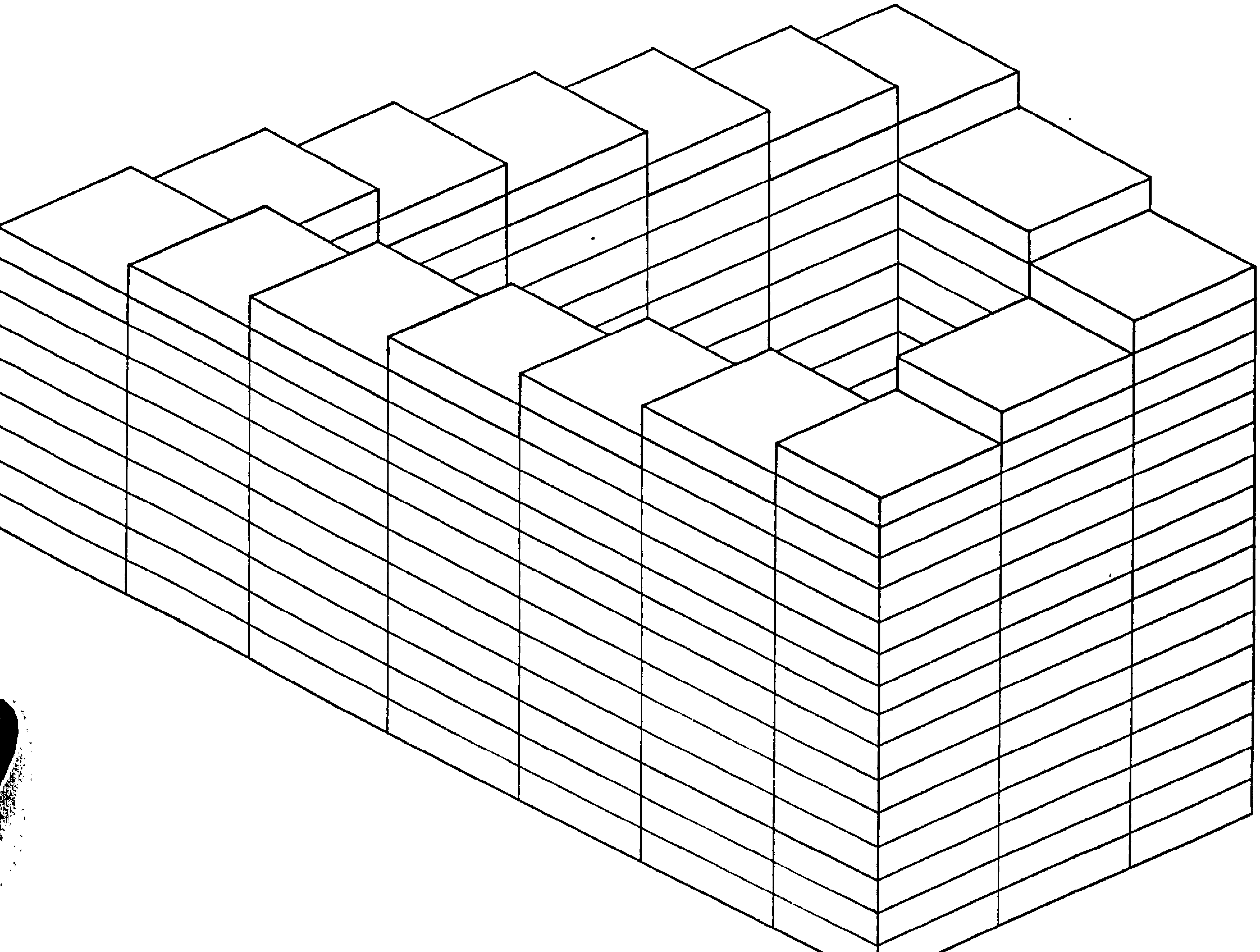
OSCILLATING FIGURE ILLUSION



DIAGONAL ILLUSION



AN IMPOSSIBLE FIGURE



THE MAGIC STAIRS

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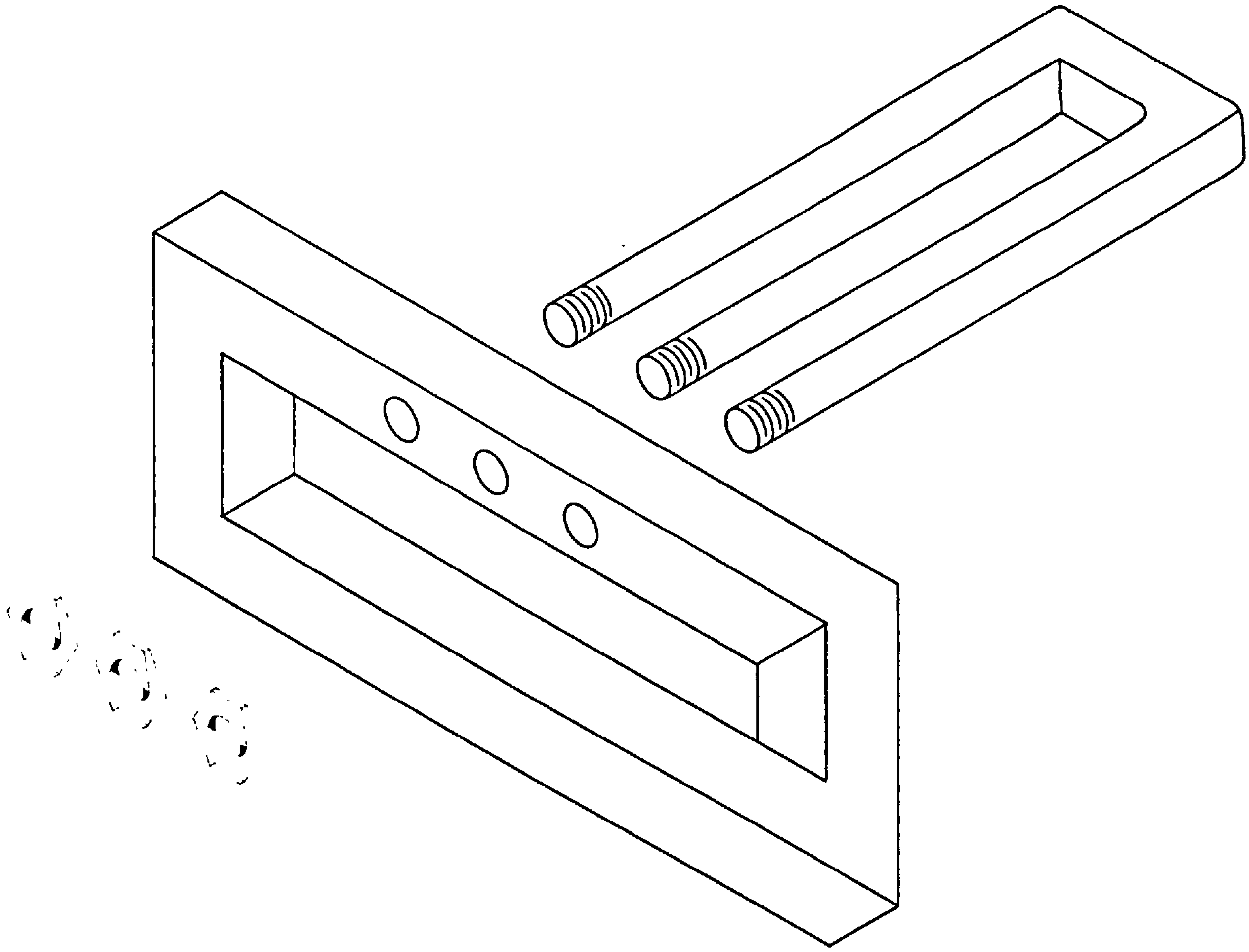


IMPOSSIBLE OBJECTS ILLUSION

VIII. OUR DEPENDENCE ON SIGHT

All of us take our sight for granted. When we close our eyes it is done voluntarily and it is usually to either block out for the moment some unpleasant scene or to go to sleep. But always we have the choice of whether or not to see.

To appreciate how important sight is we need to imagine what it is like to be blind. We know that to become permanently blind would be very depressing. Not only would we miss the various pleasures that sight gives us, but our ability to function effectively would be seriously curtailed.

In order to give you some idea of what it is like to be blind, and therefore gain some appreciation of your sense of sight, you will carry out a special activity.

Blind-Walk

In this activity you will take a walk blindfolded about the school. You should work in pairs. In the first half of the activity one of you will act as a guide and the other will be blindfolded. In the second half of the activity you will reverse roles.

When all blindfolds are in place each "blind" student should walk out of the room holding on to his sighted partner's arm. His sighted partner should lead him down the hall, up and down stairs, around corridors, etc. The blindfolded student should not touch any objects except the arm of his sighted partner.

After about 10 minutes, the sighted partner should tell the blindfolded student where he is with respect to the science classroom and the "blind" student must then feel his way back to the classroom by himself. His sighted partner should remain with him at all times to warn him of impending dangers such as stairs and tables but should not direct his movements.

When they are back in the room the two students should reverse roles and repeat the experiment.

You should then discuss as a class your experiences.

Braille

An ingenious alphabet of raised dots developed by a French man, Louis Braille in the first half of the 19th century, enables the blind to read. In the Braille system, various combinations of from one to six dots are used to represent letters and short words. By running his fingers over the raised points, an experienced blind person can read at the rate of 50 words per minute. Braille, who was blinded in an accident at the age of three, developed the reading system when he was teaching at the Institute for the Young Blind in Paris.

A Braille card with the alphabet and a special message is presented on the next page. Notice that the patterns of dots have no resemblance to the printed letters we see. Why should they?

After studying the alphabet code presented try and determine the message printed at the bottom of the card.

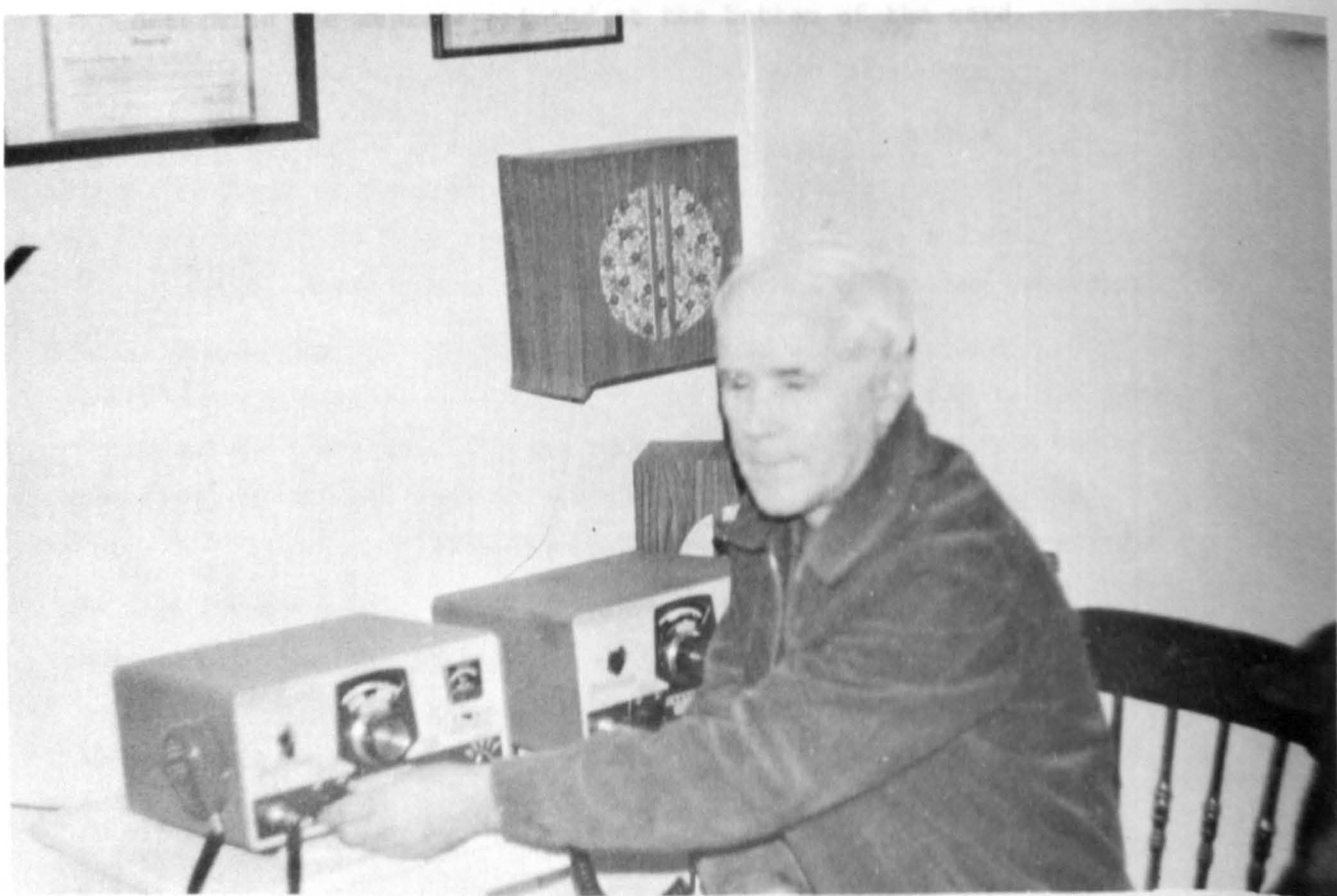
THE BRAILLE ALPHABET

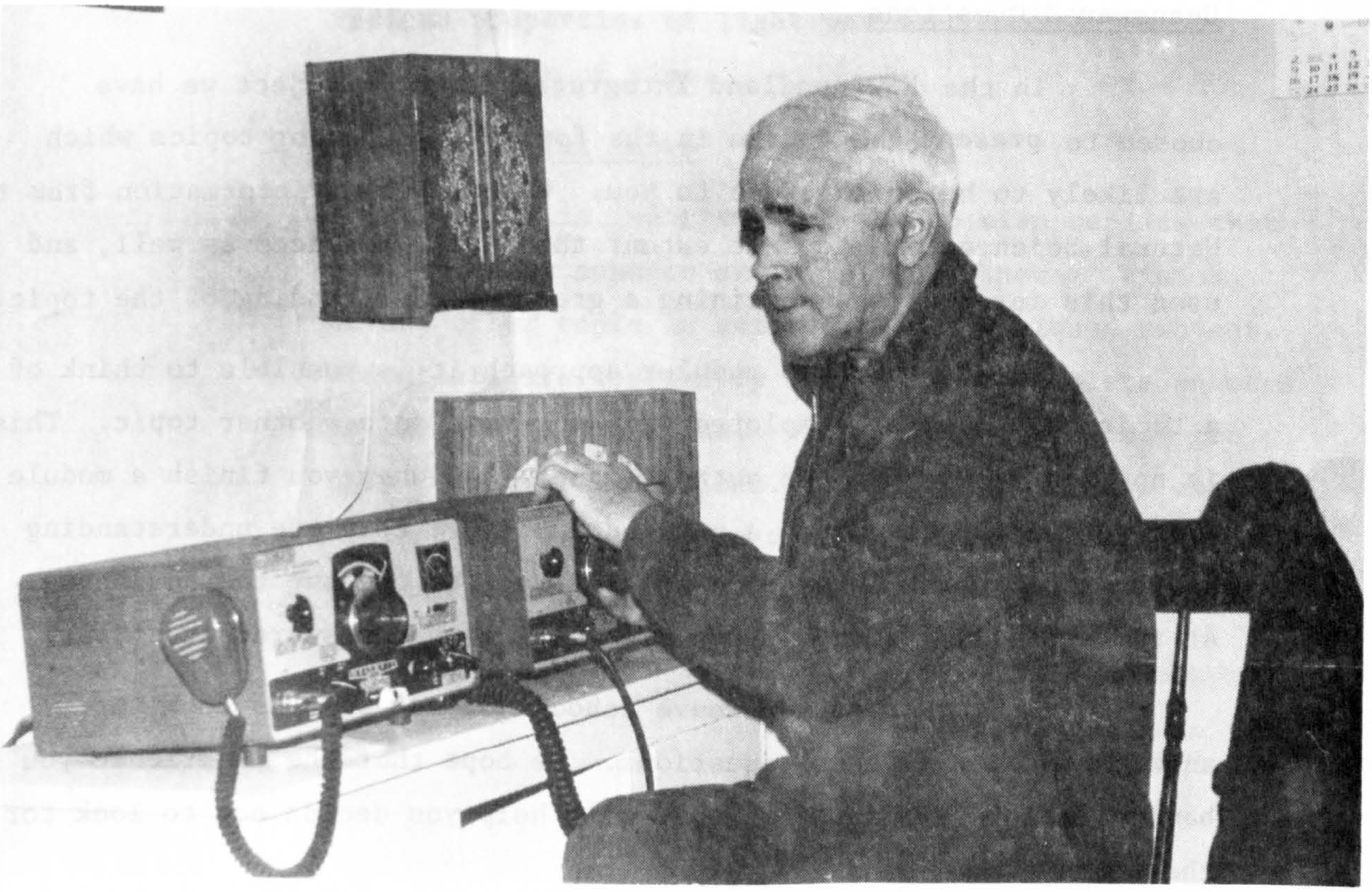
Made available courtesy CNIB.

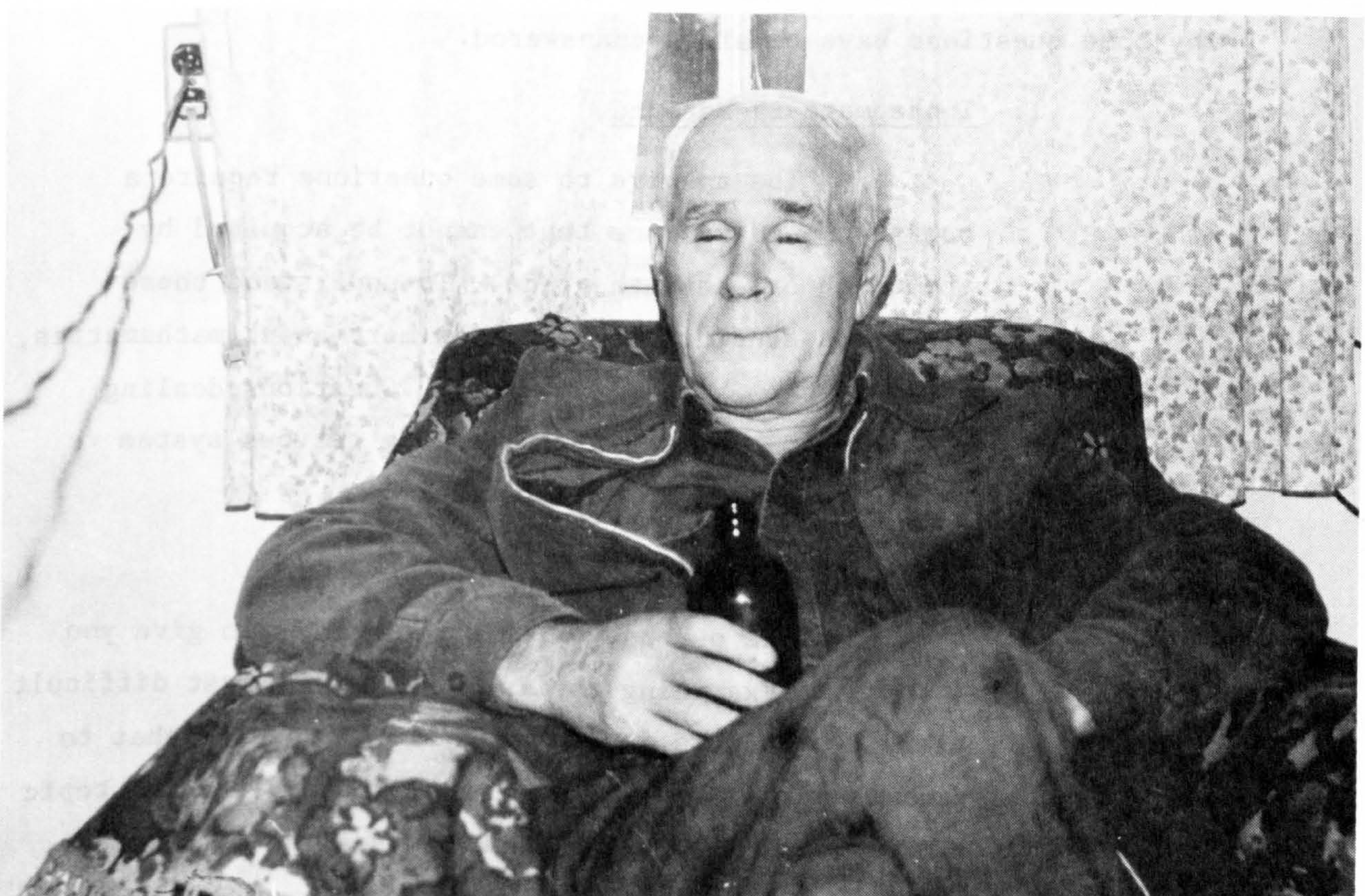
Blindness - A First Hand Account

A person's reaction to blindness depends on a number of factors, a few of which are, the age at which he became blind, his personality, his psychological background and his desire to continue an active life despite his handicap.

Mr. Austin Stewart of Glovertown Regional High School has recorded on tape an interview with his close friend, Mr. Stewart Butt. Mr. Butt, who is now 60 years old became blind at the age of nineteen. His reaction to blindness, the problems he encountered and the ways in which he has learned to cope with his situation make for fascinating listening.







Unanswered Questions

In the Newfoundland Integrated Science Project we have chosen to present the course in the form of modules or topics which are likely to be of interest to you. We have taken information from the Natural Sciences and to some extent the Social Sciences as well, and used this information in gaining a greater understanding of the topic.

Because of this modular approach it is possible to think of a topic as closed or completed when you move onto another topic. This is not the case. We, the authors, hope that when you finish a module that you will have gained a new and much more complete understanding of the topic. But in a sense this is not the end but the beginning. At the end of any module there are still many unanswered questions.

Later, after you leave school you may want to look for answers to some of these questions. We hope that the experience you have gained in examining a topic will help you decide how to look for these answers.

In the case of this module, vision, there are three reasons why some questions have remained unanswered.

1. Inadequate Background

   The answers to some questions require a background in science that cannot be acquired by the tenth or eleventh grade. To understand these answers a student needs to know more about mathematics, biology, chemistry and physics. Questions dealing with the role of the brain and the nervous system in vision fall into this category.

2. Insufficient Time

   The purpose of this program is to give you a start in examining topics. One of the most difficult tasks the authors faced was that of deciding what to leave out of the module in order to complete the topic in a reasonable time. Questions dealing with motion pictures, vision and art, moving illusions, and various properties of light was not covered because of lack of time.

3. <u>Answers Not Yet Known</u>

It is important for you to also realize that in some cases answers are simply not known. Vision, or any other topic in science is not a closed subject. Scientists are constantly seeking more complete answers to their many questions. Often the answers they get only raise more questions. This is part of the excitement of science. In the case of vision, questions on colour vision, visual evaluation, and illusions still do not have complete answers.

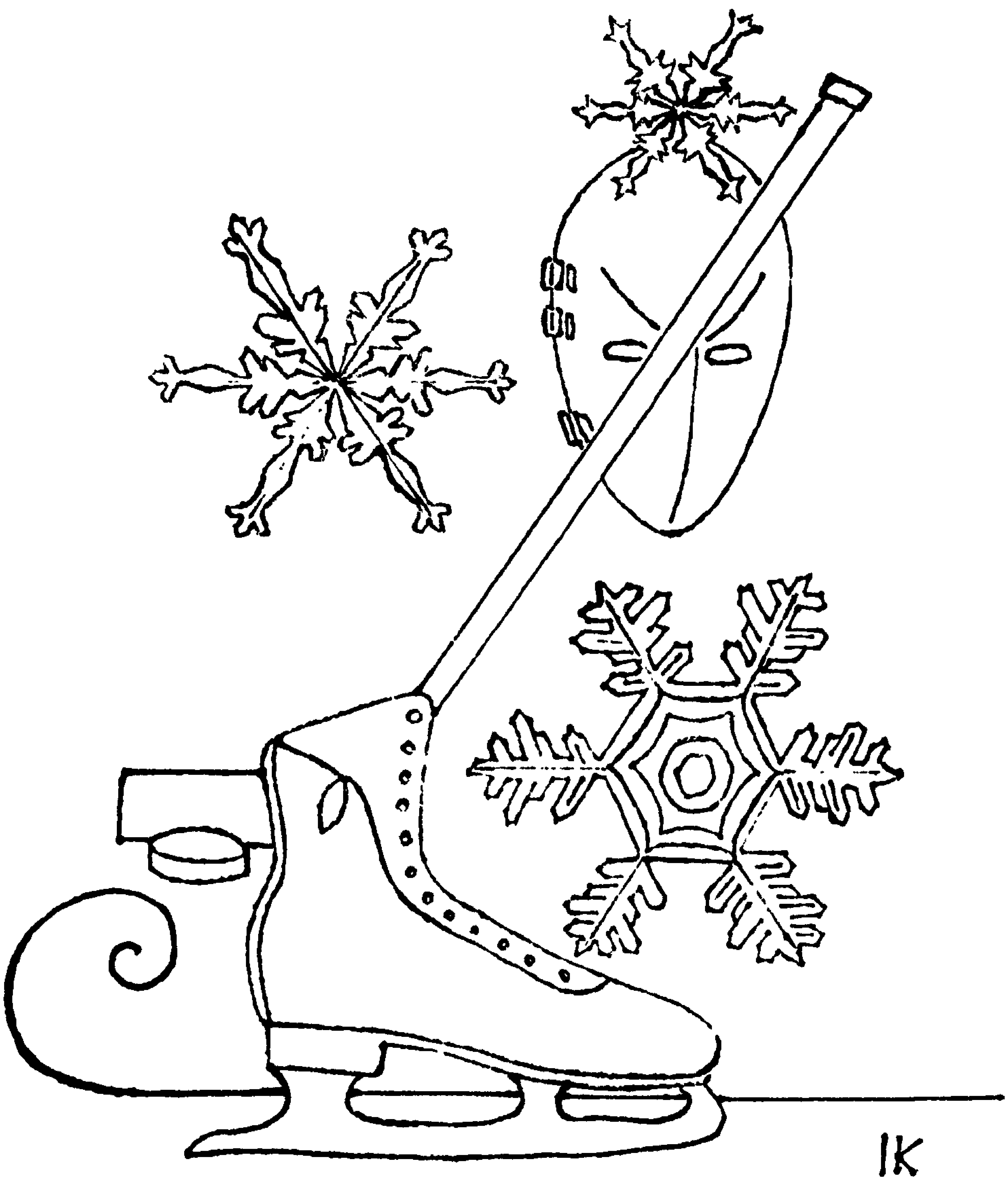
INTEGRATED SCIENCE FOR NEWFOUNDLAND

MODULE III – ICE SKATING

SCHOOL: ______________________________

NAME: ______________________________

ICE SKATING



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I. INTRODUCTION

Ice skating is probably the most important sport in Canada, and most of you will enjoy skating either in organized sport or simply for relaxation. In this module you will examine some of the aspects of skating from the standpoint of science. You will consider something of the nature of ice, a unique substance, with several unusual properties. You will also look at motion on the ice, and the energy needs of a skater, as well as some cultural aspects of the phenomenon of skating. You will learn about a number of concepts and principles that will be of use to you in a variety of situations that you will experience after you leave school. We expect that you will also have an enjoyable time.

It is hoped that you will be able to spend the first class lesson on the ice, and if you do, apart from simply skating for enjoyment, try to answer the following questions. We will refer to the answers and observations that you will make later in the module.

a. Sketch the shape of the bottom of your skate blade. Does a hockey skate differ from a figure skate?

b. Stand on one skate on a sheet of paper. Measure and calculate the area of the imprint. Record it below.

c. How deep in the ice does a skate cut? Does this vary with bodyweight?

d. Examine some ice after a person has just skated on it. Has any of it melted?

e. One of the unique characteristics of running is the observation that at sometime in the runner's stride, both feet are off the ground. Can you run while skating? Try it but be careful.

f. Time the fastest person in the class over a fixed distance. How would this compare to someone running the same distance?

g. For each person there is a single walking speed that is most comfortable. That is, you will be uncomfortable if you walk too fast or too slow. Try and find out your most comfortable skating speed. In what way is it different for different people?

h. Skate at top speed for 30-40 metres. How many breaths do you take?

II. PROPERTIES OF ICE

Skating depends on the ice! Of course you know that, but in fact it is the unique nature of ice that makes it so suitable as a substance on which to skate. In this section we will examine some of the properties of ice which make it such an unusual substance.

The Melting Point of Ice

Add a mixture of ice and water to a beaker and stir. Place a thermometer in the middle and note the temperature in degrees centigrade. Observe carefully the temperature on the thermometer. Is it a coincidence that it is exactly $0^{o}C$? Explain your answer.

Add some salt and stir the mixture. Is the melting point still $0^{o}C$? Try this experiment adding a variety of other substances to the ice and water. Record your observations below.

Although the melting point of ice and the freezing point of water are normally 0°C, the value varies with different conditions. The value changes slightly with atmospheric pressure, and also with the purity of the water and the ice.

In this next activity you will investigate the effect of impurities on the freezing point of water. First of all we need a method of cooling water in the laboratory, obviously a refrigerator would serve the purpose however it is not very convenient to use for class experiments. Instead you will use freezing mixture. This consists of a mixture of crushed ice and salt, and will enable you to freeze a test tube of water quite easily and enable you to make convenient observations of the temperature.

Cover the bottom of a container with about 2 cm. of cracked ice, cover this with a layer of kitchen salt, then another layer of ice, and then a layer of salt until the container is 2/3 full. Half fill a test-tube with water, and immerse it in the mixture. Record the temperature at which the water freezes.

Repeat with water containing different dissolved solids, such as salt, sugar, etc. You can do several observations at the same time, providing you are careful. Note the freezing points of the different solutions below.

What effect do dissolved substances have on the freezing point of water?

Do you think the sea, and ponds freeze at exactly $0^{\circ}C$? Explain.

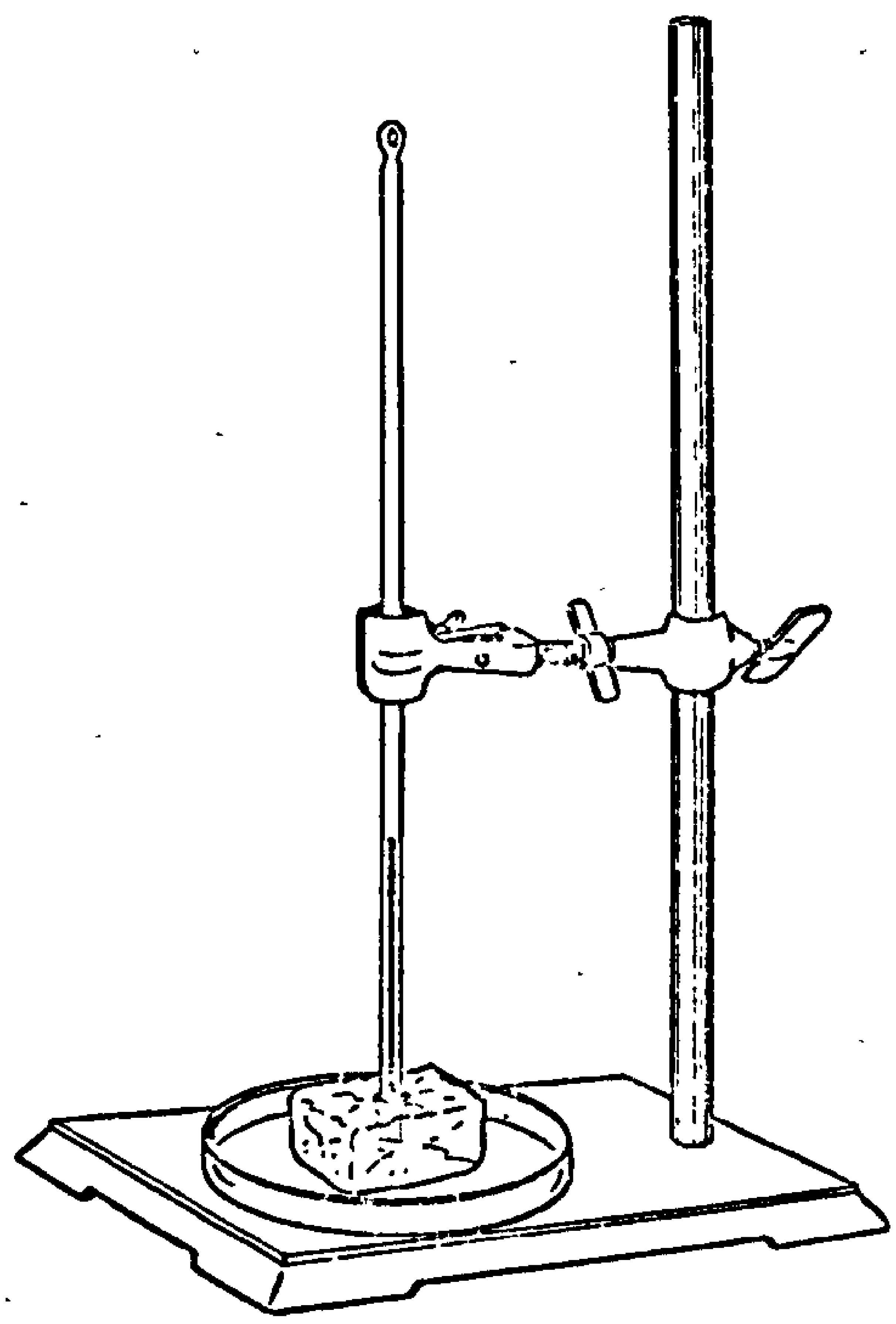
The effect of impurities on the behaviour of water is considerable. An interesting phenomena allegedly discovered in 1967 was Polywater. Two Russian scientists announced that they had produced a different form of water. It was made of hydrogen and oxygen, but its structure was different to that of ordinary water. It was 15 times thicker than ordinary water and its freezing point was $-40^{\circ}C$.

Scientists in several different countries tried to make Polywater, however the results were not conclusive. The new form of water was only produced in very tiny amounts, too small for thorough analysis. Eventually two main ideas were put forward. First that polywater was a new type of water, and second that it was not a new type of water, but rather it was ordinary water containing impurities. Because polywater could only be produced in very small amounts Scientists were not able to compare samples produced in different laboratories. Eventually new techniques were developed for analysing Polywater which showed that it was infact impure water.

The story of Polywater illustrates several important aspects about science and scientists. Firstly, experiments must be able to be repeated by other people for them to be acceptable. That is why the conditions of the experiment must be carefully stated. Secondly, scientists do not always agree with each other on what certain results mean.

Often it may take a new technique, or the development of a new instrument before an issue can be finally decided. Science is not so clear cut and straight forward as we like to think. It may take a long time before a new theory or discovery is accepted, and often the fond ideas of scientists end in the waste basket, rejected by their colleagues.

Drill a small hole in a block of ice sufficient in size to contain the bulb of a thermometer. Support the thermometer as shown in the diagram so that it will not fall over. Observe the temperature every two minutes until all the ice has melted.



Plot a graph of your results, with time on the horizontal axis and temperature on the vertical axis. Draw on your graph a line representing room temperature during the experiment. Answer the following questions from the graph.

(a) How long does the temperature of the ice remain constant?

(b) During this time is the ice warmer or cooler than room temperature?

(c) Does the ice give heat to the room, or receive heat from it?

(d) Why does the temperature of the ice remain constant for a period of time? What do you think the heat absorbed is being used for?

Rate of Melting of Ice

We are all aware that ice melts as it is exposed to higher temperatures, but what decides whether it melts quickly or slowly. There are in fact a number of factors which affect the time it takes for an ice cube to melt. List as many below as you can.

One factor which might affect the time it takes for an ice cube to melt is the surface area of the cube. Make a guess, we call it a hypothesis, as to the way in which a change in surface area of an ice cube affects the length of time it takes to melt.

In your hypothesis there are two variables. What are they?

Which variable will you change during the experiment? This is called the independent variable.

The other variable which changes as a consequence of changes in the independent variable, is the dependent variable.

The other factors that might influence the rate of melting of the ice block are kept constant in the experiment. We say they are controlled. What are these other factors and how do you control them?

Describe briefly a simple account of the procedure you intend to follow in order to test your hypothesis. Collect and tabulate your results. It will probably be much easier if each group of students were to prepare one block of ice and measure the time for it to melt, and then pool the data. Finally draw a graph of your data, of surface area against time taken to melt. Indicate whether your results confirm or reject your hypothesis.

Assignment:

Preparing the Rink

The preparation of an ice surface is far more complex than simply freezing water. Many ice stadiums serve other functions throughout the year, and consequently the ice surface may have to be remade several times a season. The procedure used at Madison Square Gardens is noted below.

(a) 24 hours beforehand, brine 10° F. is piped through pipes under the surface.

(b) A thin film of water is then applied with hoses, this freezes, and the step is repeated two more times.

(c) The entire surface is covered with water solution containing a whitening agent.

(d) Three more coats of water are then applied with hoses and frozen.

(e) Markings are then painted on by hand.

(f) Fourteen more water spray applications.

(g) The 5/8" ice surface is then ready. Madison Square Gardens takes 6000 gallons of water.

(h) During the game a Zamboni machine picks up fine ice shavings and then applies a film of hot water to smooth the surface.

One interesting point is that hot water is used in (h). It is often said that "hot water freezes faster than cold water." Devise an experiment to test this statement. Pay attention to all the factors that you have to control to test your statement. Describe the procedure you would adopt below.

The Formation and Expansion of Ice

Fill a polystyrene cup with water, and place it in the freezing compartment of a refrigerator. Observe it on a regular F. basis, say every hour until it has frozen solid.

Answer the following questions below.

(a) Where abouts in the cup of water did ice begin to form first?

(b) Was there any change in the volume of the water as it turned to ice?

Repeat the above series of observations with molten paraffin wax. This will solidify much faster, so make your observations every ten minutes.

(a) Where abouts does the solid wax begin to form first?

(b) Is there any change in volume as the liquid wax solidifies?

It appears that ice is unusual in the extent that it forms on the surface of the water. In most liquids as they solidify the solid forms at the bottom. This property of ice has considerable significance for life in ponds. Fxplain.

You should also have observed that as water changes to ice its volume increases. If water in a closed container is frozen, enormous pressure develops on the boundaries with often spectacular results as broken pipes and cars illustrate in the winter.

Density of Ice

We often carelessly make such statements as "iron is heavier than water". What is wrong with this?

One of the fundamental properties of materials is the relationship between its weight and its volume, this is termed the density of the material.

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

The units in which we measure density will be determined by those in which we measure weight and volume.

You are provided with a variety of regular shaped objects made from different materials. Using the ruler to make the necessary measurements, calculate the volumes of the objects. Then weigh them on the balance and hence calculate the density of each material. Record your results in the table below.

Material	Weight	Volume	Density	Float or Sink
Water				

Weigh a dry beaker, and then carefully pour 50ml. of water into it, weigh and hence determine the weight of the water. Record your results in the table above.

Now take each of the materials and in turn try to make them float in water. Record in your table whether they sink or float. Can you discover from the table how to predict whether a substance will sink or float in water.

Now drop an ice cube in water, what can you say about the density of ice?

Alcohol has a density of 0.8 gram/ml. What would you expect ice to do in alcohol? Check your prediction.

Now having measured the densities of some materials you should be able to answer the question "which is heavier a pound of ice or a pound of feathers?"

The Unusual Expansion of Water

Most materials contract in volume when they are cooled, thus since the mass stays the same their density increases. However, water shows unusual behaviour which accounts for the fact that ice forms at the top of a pond. Examine the graphs below which show the changes which occur in the density of water as the temperature changes. The second graph shows the changes on a larger scale.

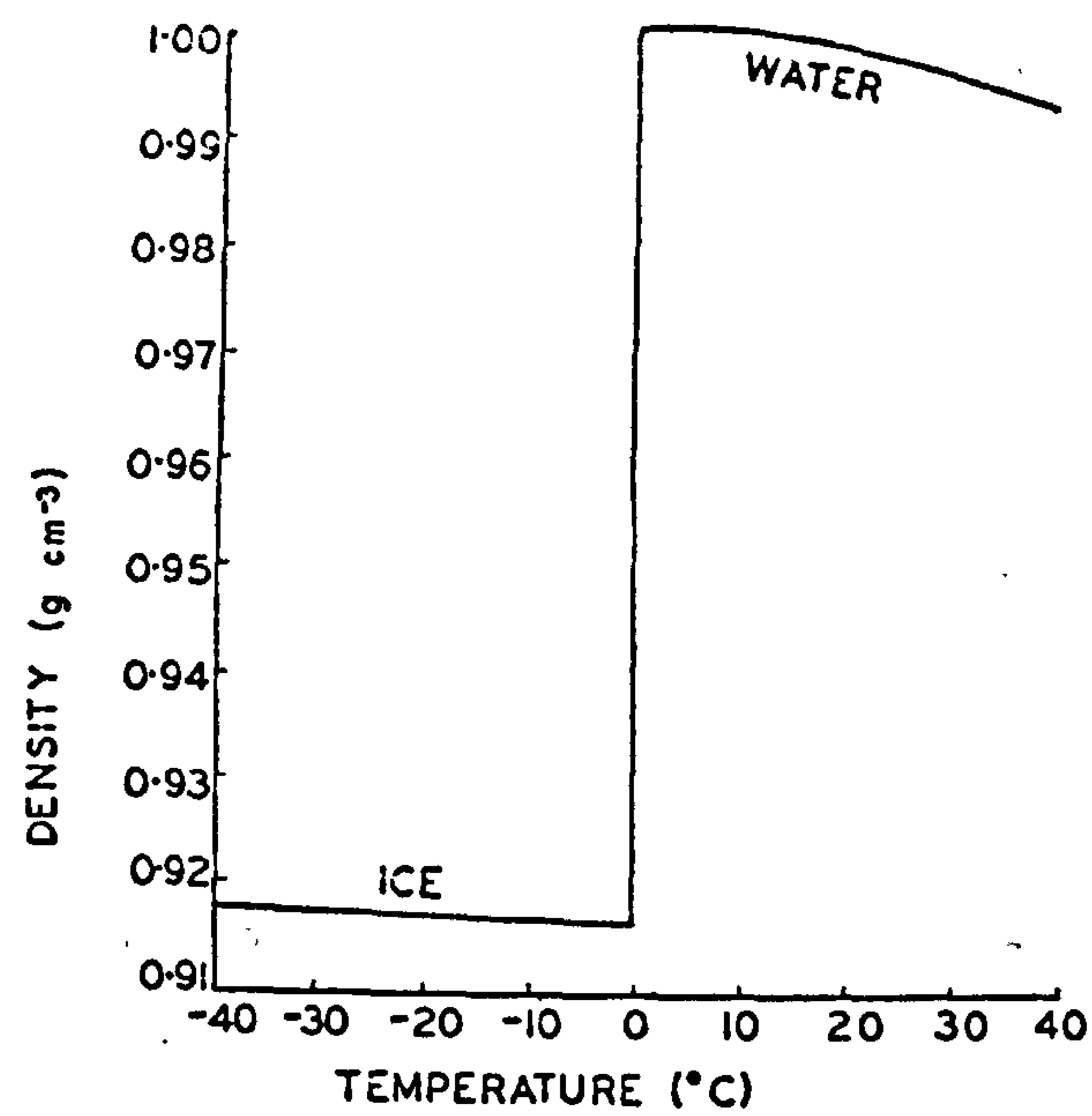


FIG. 1. The densities of ice and air-saturated water at atmospheric pressure.

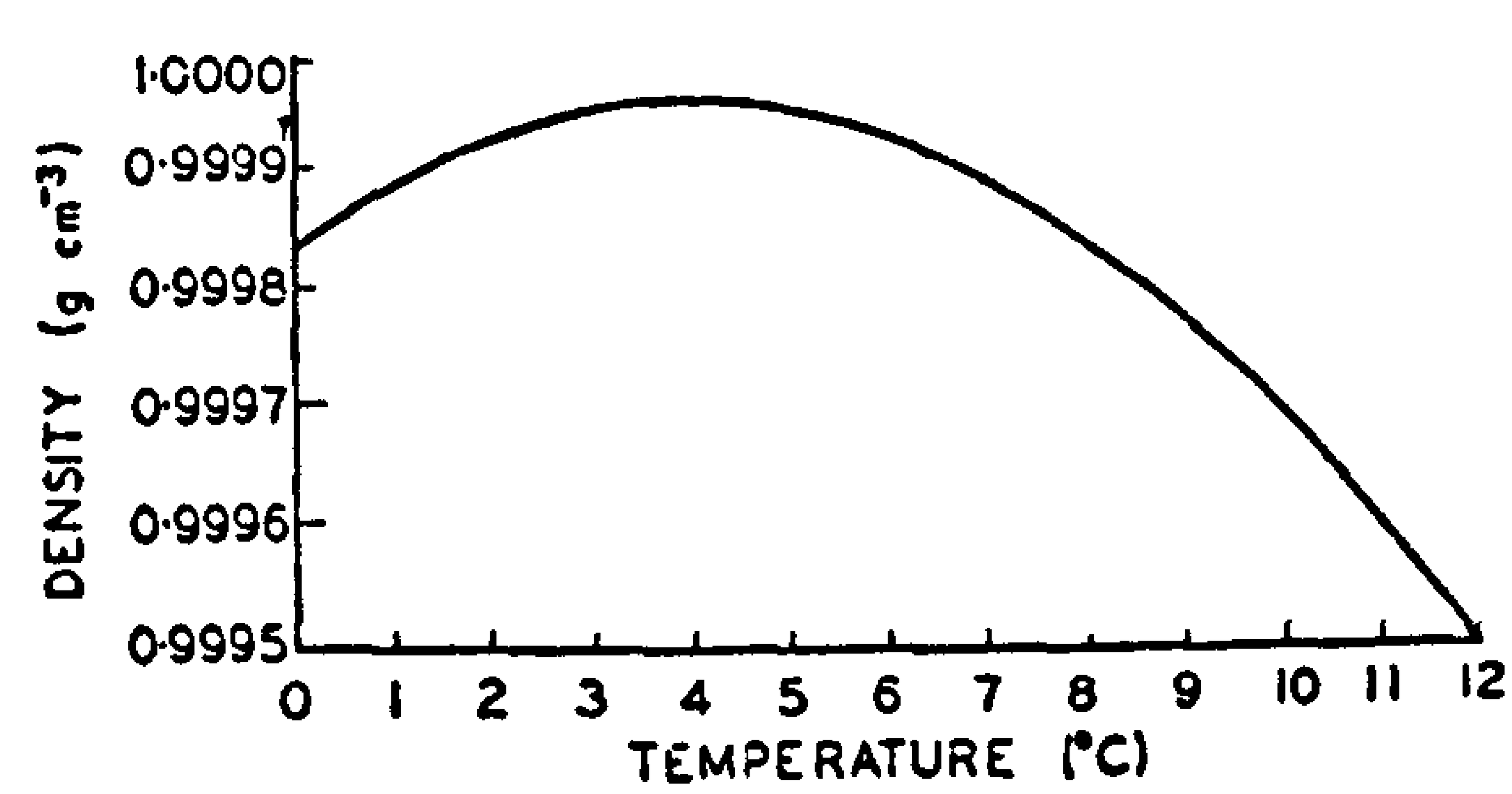


FIG. 2. The density of air-saturated water near the inversion temperature.

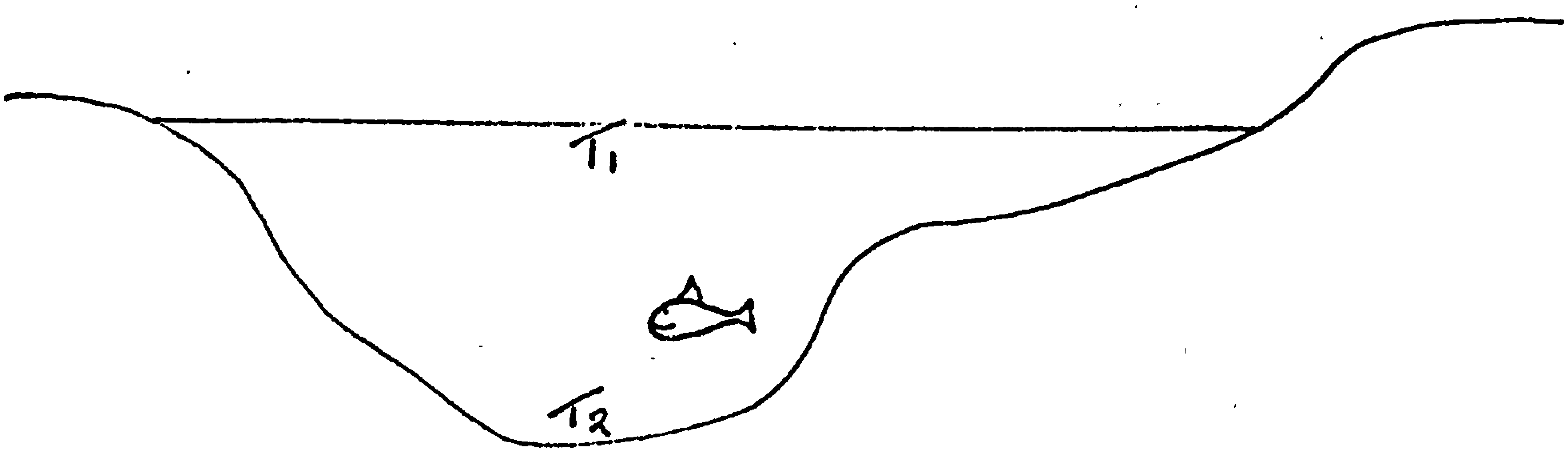
Answer the following questions from the graph.

(a) At what temperature is the density of water a maximum?

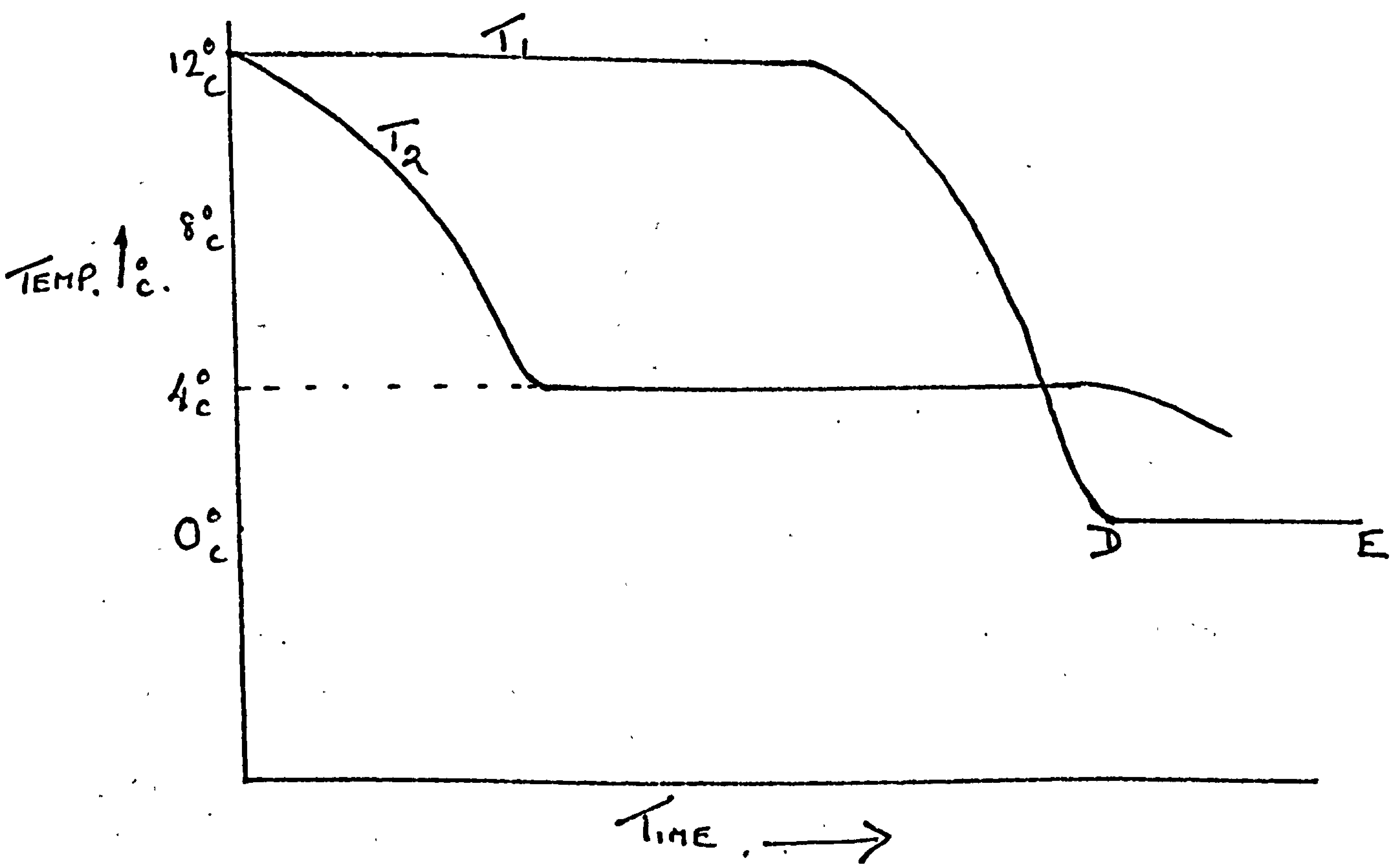
(b) What would happen to the volume of a mass of water as it cools from $10^{\circ}C$ to $4^{\circ}C$? Would it increase or decrease in size?

(c) What happens at $0^{\circ}C$ to account for sudden change in density?

Now let us look at the problem of a body of water cooling.



The graph below represents the cooling curve for a pond as the temperature is progressively lowered. The curve labelled T_1 represents the temperature of water close to the surface, and the curve T_2 water at the bottom of the pond.



Answer the following questions.

(a) Why does the temperature at the bottom of the pond drop more quickly at the beginning?

(b) Mark on the graph the time when the temperature at the top of the pond is equal to the temperature at the bottom.

(c) What is happening along the line D.E.?

(d) Where does ice form first?

The unusual properties of ice can ultimately be traced to the shape of the water molecules and the bonding that occurs between them in the ice crystal. The following short extract from the Time - Life book on 'Water" gives us some idea what would happen if water behaved like other substances as it solidified.

A nonconforming substance

The lopsidedness which endows the water molecule with such potency as a solvent is also indirectly the source of other exceptional properties. The most significant of these is often overlooked because it is so simple: ice floats. By all the rules of physical behavior it should not. Almost every substance, whether solid, liquid or gas, will shrink in volume as its temperature goes down. As it contracts, it grows more dense. Thus in its liquid form it is heavier than as a gas, and its solid form is heavier than its liquid.

Water follows this rule precisely as a gas and, as a liquid, for 96 per cent of the way down the temperature range to its freezing point, shrinking steadily all the way. But at 39° F. something happens. As cooling continues the water expands and gets lighter, and as it freezes into a solid at 32°F. it becomes still lighter, until it has finally gained about 9 per cent in volume.

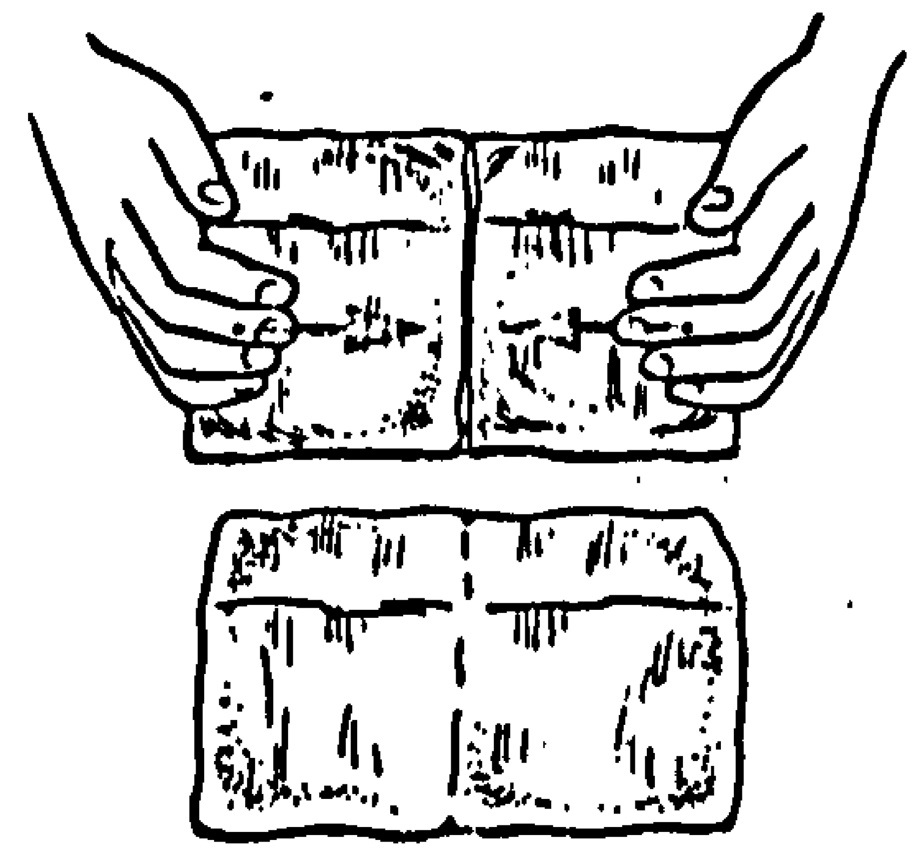
However inconvenient this expansion of ice may be for the householder faced with burst water pipes after a sudden winter freeze, it is fortunate for the rest of the world.

If water behaved like other freezing liquids, there would soon be no life on the earth, for the water would be irrevocably locked in eternal ice on the beds of seas, lakes and streams. As it is, when winter comes, ice forms and floats on the surface of bodies of water, forming an insulating skin which protects the water beneath from further freezing. If ice were heavier than water, it would sink to the bottom and gradually build up from there. Before long the lakes and Arctic seas which now are only superficially covered with ice would be frozen solid, with perhaps thin layers of liquid water over the ice where it melted during the warmest seasons. Most of the world's water supply would become unusable to plants, animals or man.

One of the most spectacular effects to follow such a circumstance would be enormous changes in the world's climate. In this icebound world the daily fluctuations of temperature would amount to hundreds of degrees, seasonal variations would be even more radical, and the winds that blow around the world would be parched and searing. For the climate of the world is tempered by the ability of water to soak up and store the sun's heat and to release it slowly.

<u>When the Skate Meets the Ice</u>

We are aware that ice is slippery, it has less friction, less opposition to motion, than other surfaces. However, this slippery nature of ice is not the only reason why a skater moves easily on ice.



Press two blocks of ice together. What happens?

The blocks freeze together because the pressure exerted causes the ice to melt, and then when the pressure is released the water freezes once again to hold the blocks together.

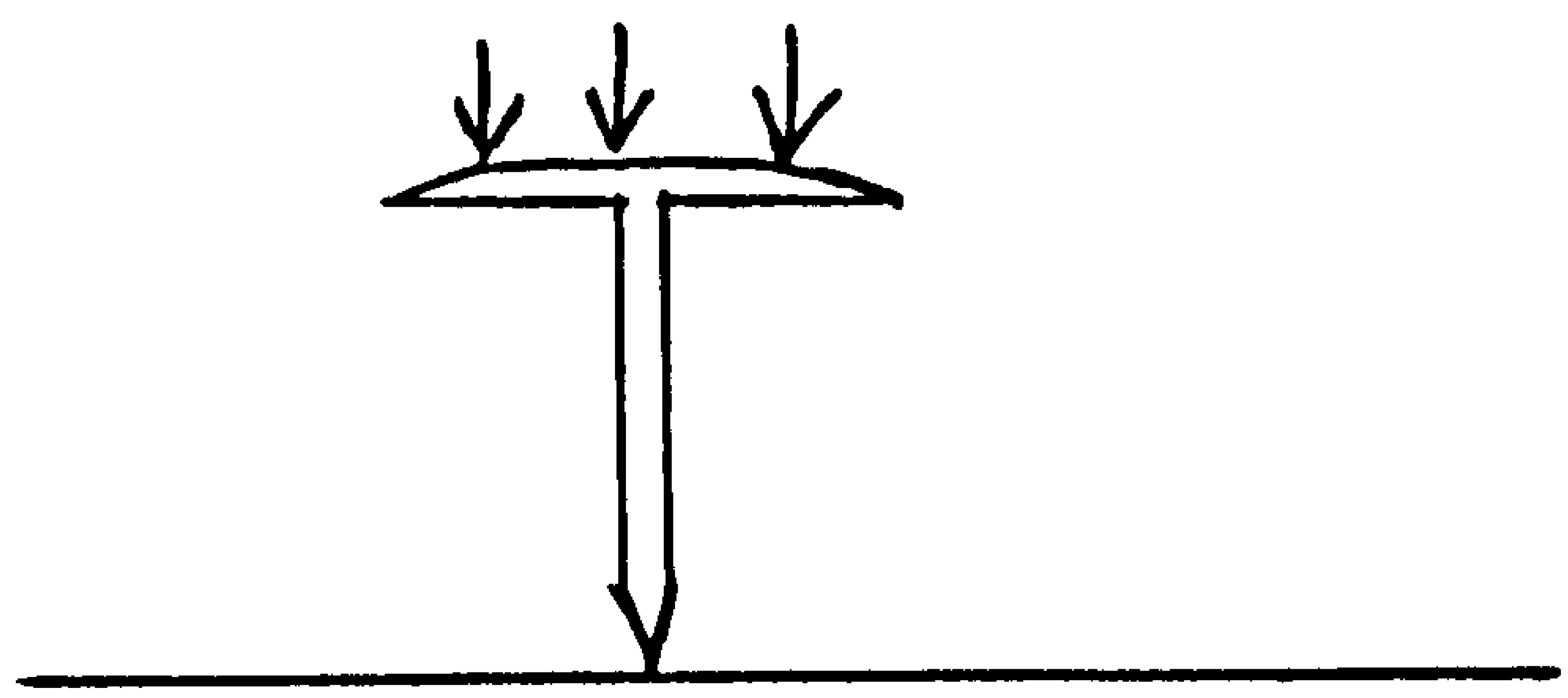
What effect does pressure have on the melting point of ice? Does it raise it or lower it?

Your teacher will arrange for you to see another example of the effect of pressure on the melting point of ice. Describe it and record your observations and explanations of the phenomena.

What in fact do we mean by the term pressure? Pressure is the relationship between force and area.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

If we suspect we are walking on thin ice we put a plank on the ice and walk on that in order to distribute our weight. Similarly snow shoes cover a large area in the snow in order to reduce the pressure exerted by the walker. A thumb tack operates on the reverse basis.



The area of contact being very small the pressure at the point of contact is high and thus it is easy to push the thumb tack in.

You may remember that when you were skating at the beginning of this module you measured the area of contact of the blade with the ice.

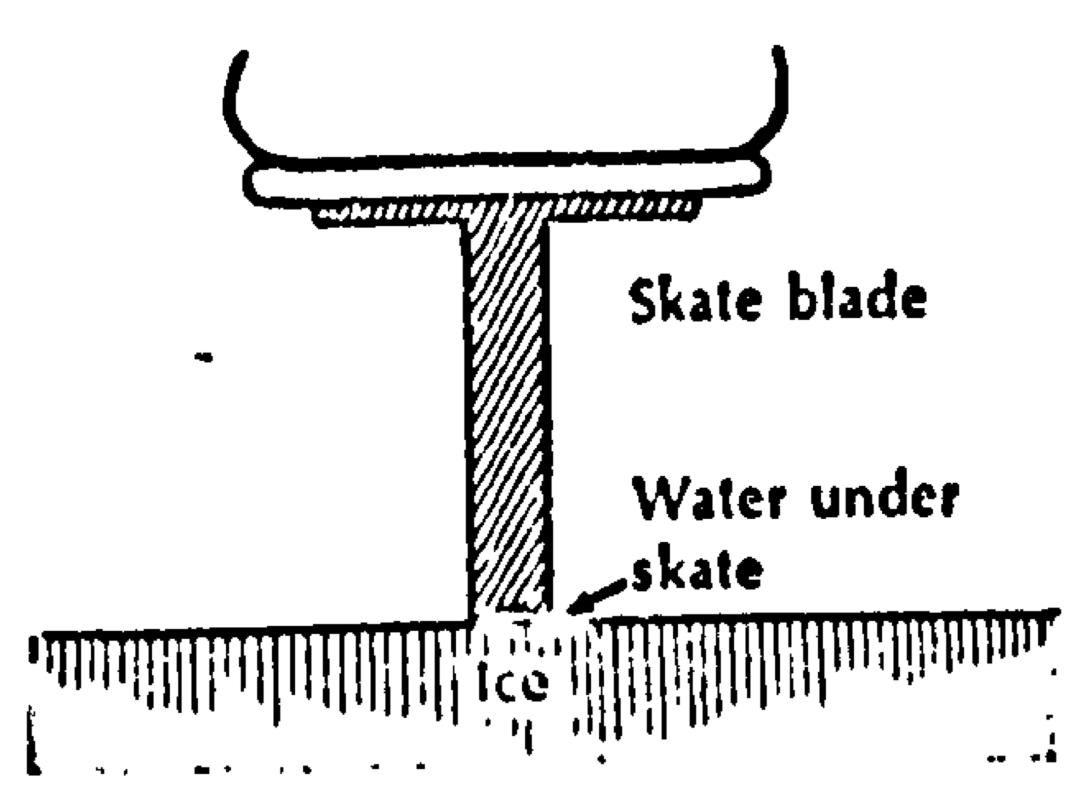
Area =

Your Weight =

Calculate the pressure you exert standing

(a) on one leg

(b) on two legs



The small surface area of the blades means that the pressure exerted on the ice is great. This high pressure causes the ice to melt and the water acts as a lubricant as the blade moves along. After the blade has passed the ice refreezes again.

Now in fact the above explanation of why a skate moves so easily over ice, is the traditional one which has been put forward for many years, and is usually found in most elementary physics textbooks. However, many objections have been raised to it, based on the fact that the pressure exerted may not be sufficient to melt the ice. Can you think of any alternative theory which would account for the way in which a skate melts the ice?

Assignment:

1. Measure the area of a snow-shoe, and compare the pressure exerted by it with the pressure exerted by a normal shoe. Assume you would be using both.

2. Find out the recommended method for rescuing someone who has fallen through the ice, how do you reduce the pressure you exert on the ice in such a situation?

Project:

In this section you used an ice-salt mixture to freeze different solutions. Before refrigerators were in common use, the ice-salt mixture was used to freeze things and make such delicacies as ice-cream. If you have enough salt-ice mixture available you can make some ice-cream in the classroom using the simple recipe below:

You need for this ice-cream the following ingredients

½ pint milk	3 egg yolks
3 ounces sugar	½ pint evaporated milk

Warm the milk with the sugar, pour onto the egg yolks in a pan beating all the time. Heat the pan gently until the mixture thickens (Do this on a double boiler if one is available.) Allow the mixture to cool. Whip the evaporated milk until stiff, and fold in this mixture. Turn the mixture into a container and surround it with freezing mixture. Stir periodically until it is frozen.

III. MOTION ON THE ICE

Of all sports, skating more than any other gives the impression of speed, and motion. Few people can fail to be impressed with the pace of a professional hockey game, or the movement of a speed skater, who may obtain speeds of 40-50 kilometers per hour. In this section we will consider some of the basic aspects of motion, the study of which is called kinematics. Much of what you learn with respect to skating you will be able to apply later in the study of other moving objects such as cars, airplanes, birds and rockets.

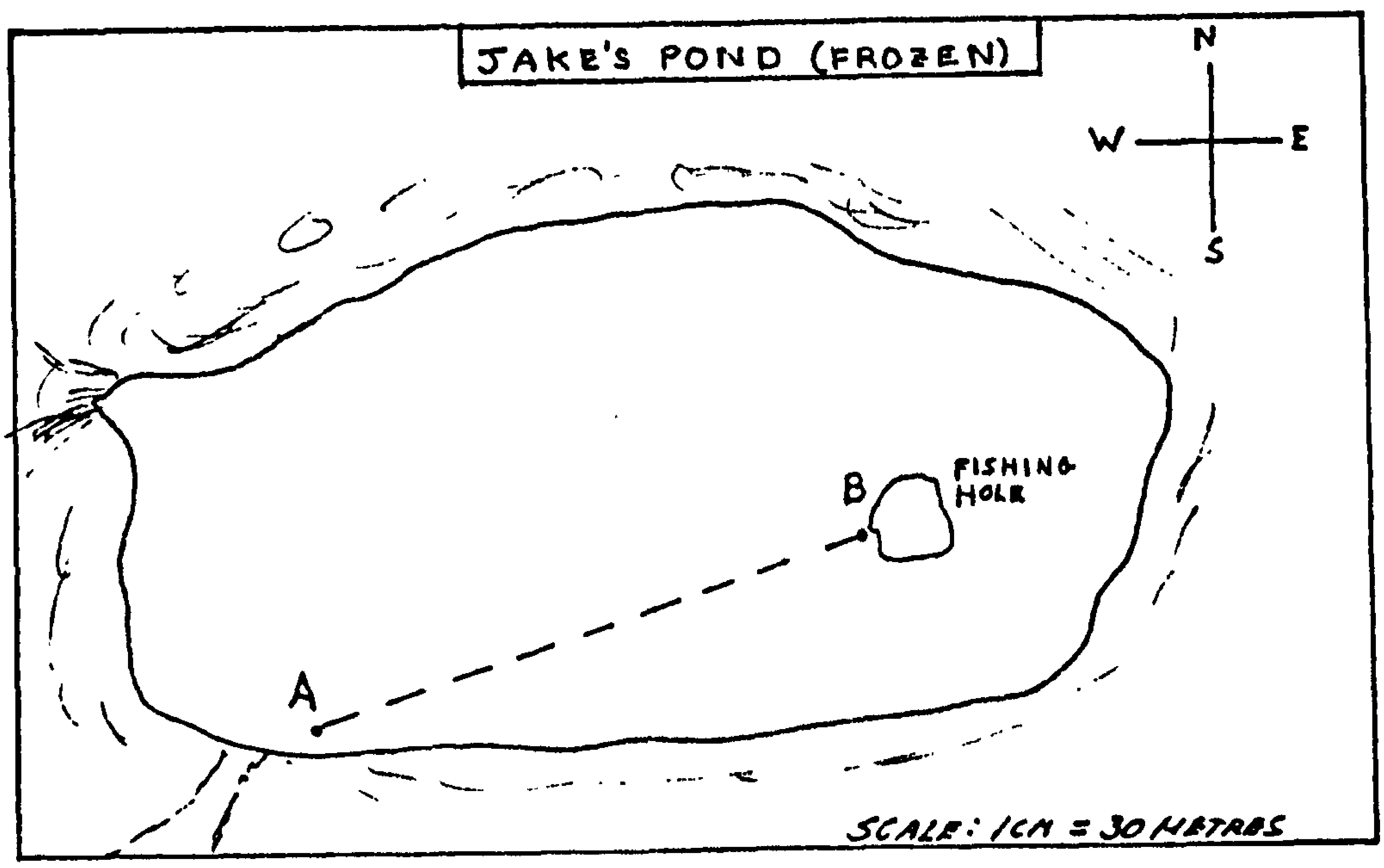
Time and Distance

When we think of motion a number of specific words come to mind. Some of these are: distance, direction, displacement, time, speed, velocity, and acceleration. There are others. All of us have some idea of what these mean. However, in order for us to study motion in the same way we will all need to have precise definitions for each of these words.

We can begin by looking at the units we use in measuring these quantities. Distance is measured in units such as, inches, centimeters, and feet. What are some other units of distance that are commonly used?

Time is measured in such units as seconds, minutes, hours, days and years. Direction is measured with reference to points or angles. We talk about going north, northeast, southwest, 30° east of north and so forth.

Below is a top view of a frozen pond, with compass directions shown in the upper right hand corner.

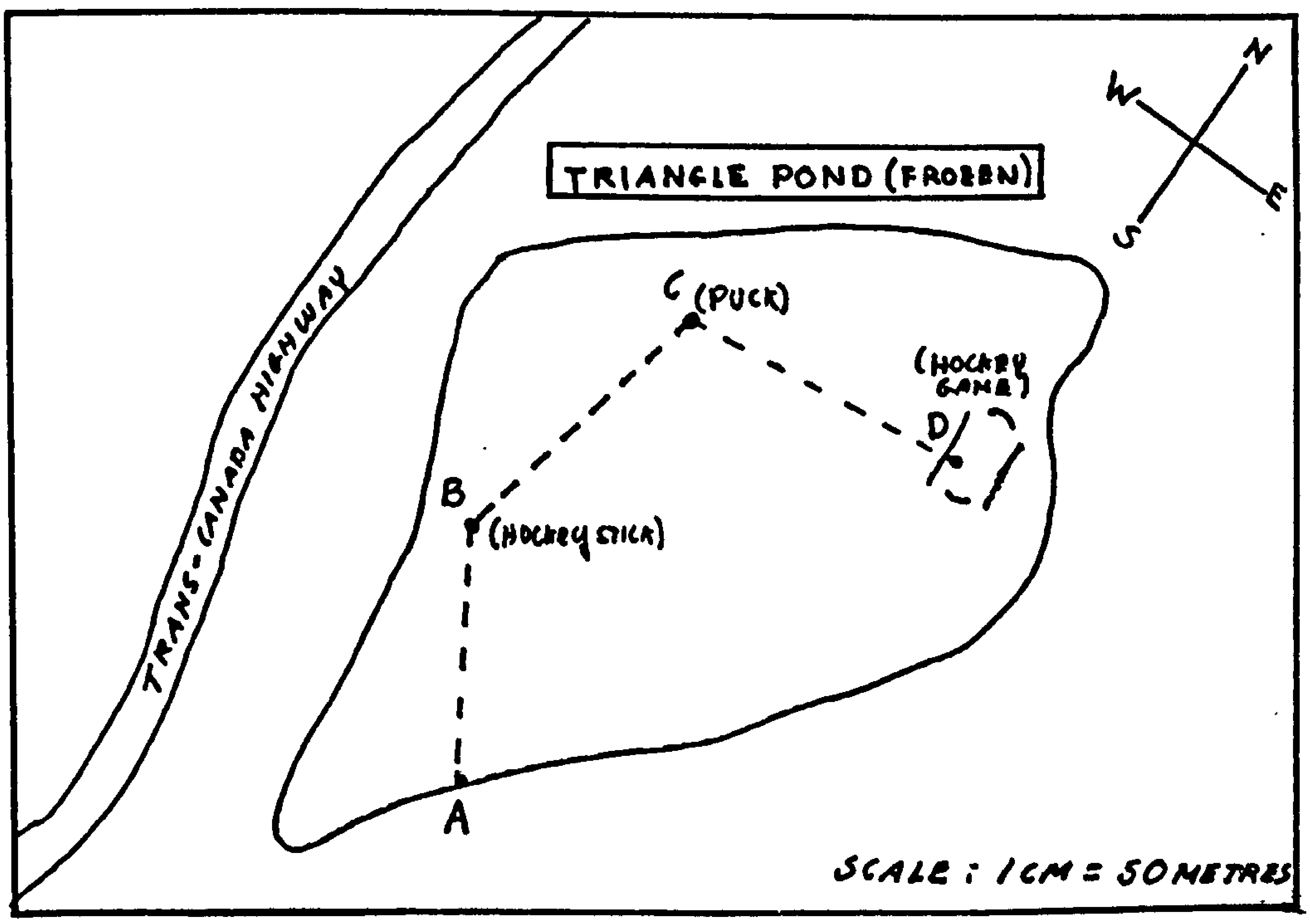


Suppose our skater wanted to skate from the shore at point "A" to the fishing hole in the ice at point "B". Using your protractor determine the direction he would have to head. Measure your direction in degrees east of north. What would be your answer if you were measuring direction in degrees north of east?

Distance, time, and direction are referred to as basic or fundamental quantities because they have only one unit. Mass and electric charge would be other examples of fundamental quantities. Other quantities such as speed, displacement, and acceleration are not fundamental because they are measured in terms of two or more basic units. Other examples are force and energy.

Let us consider displacement. Displacement considers both distance and direction and is usually taken as the shortest distance between two points. For example, the shortest distance between points "A" and "B" on Jake's Pond is along the dotted line shown on the map. If this distance is 500 metres, what is the displacement between points "A" and "B"?

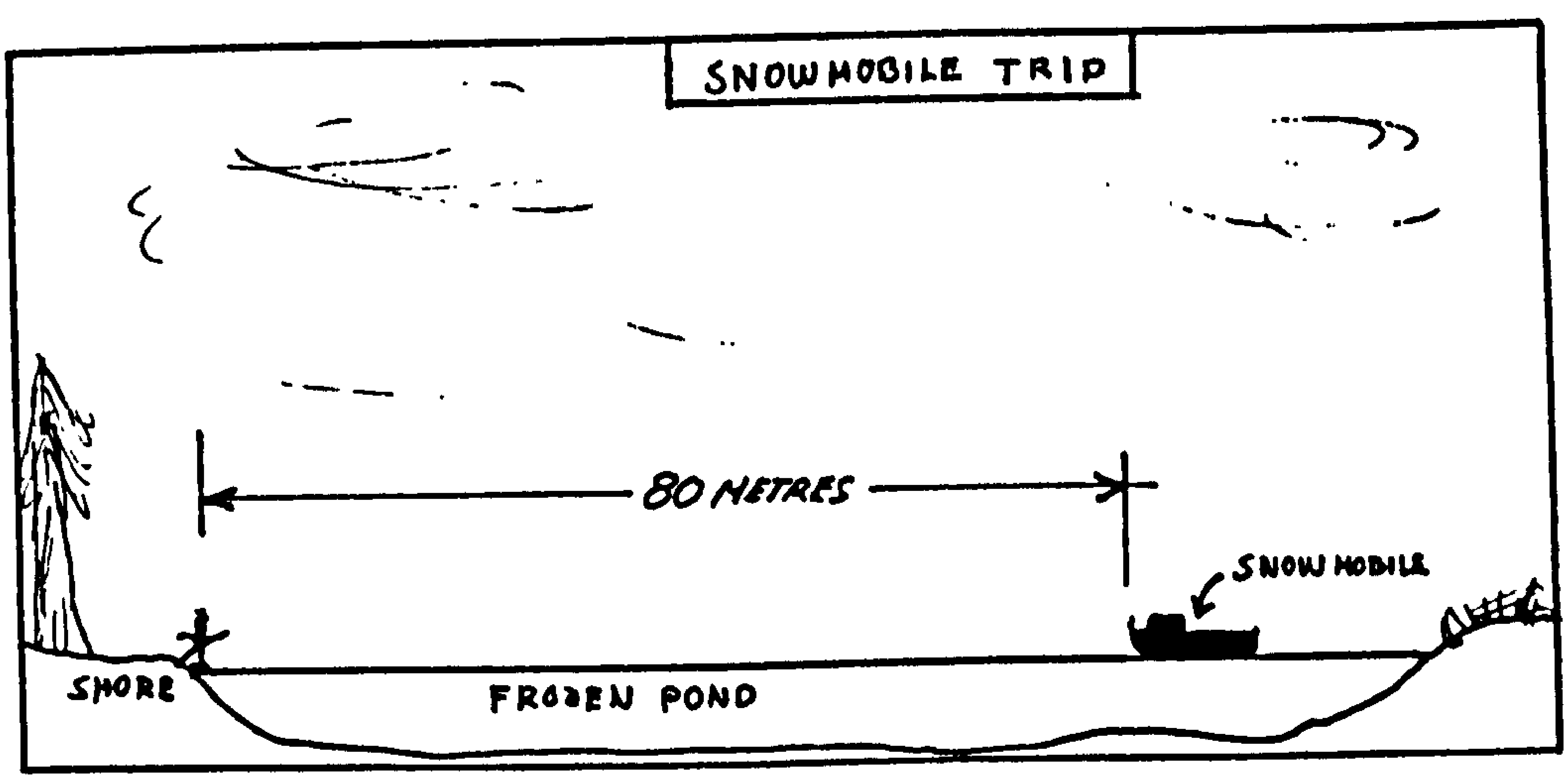
Below is the top view of Triangle Pond near St. John's.



Suppose a skater starts at point "A" and wants to go to point "D" where a hockey game is taking place. Before he gets there he has to go to point "B" where his hockey stick is, then to point "C" where a hockey puck has gone and then on to point "D". What is the total distance he skates in going from "A" to "D"? What is his displacement from "A" to "D"? You will need a protractor and a ruler. Note the scale at the bottom of the map.

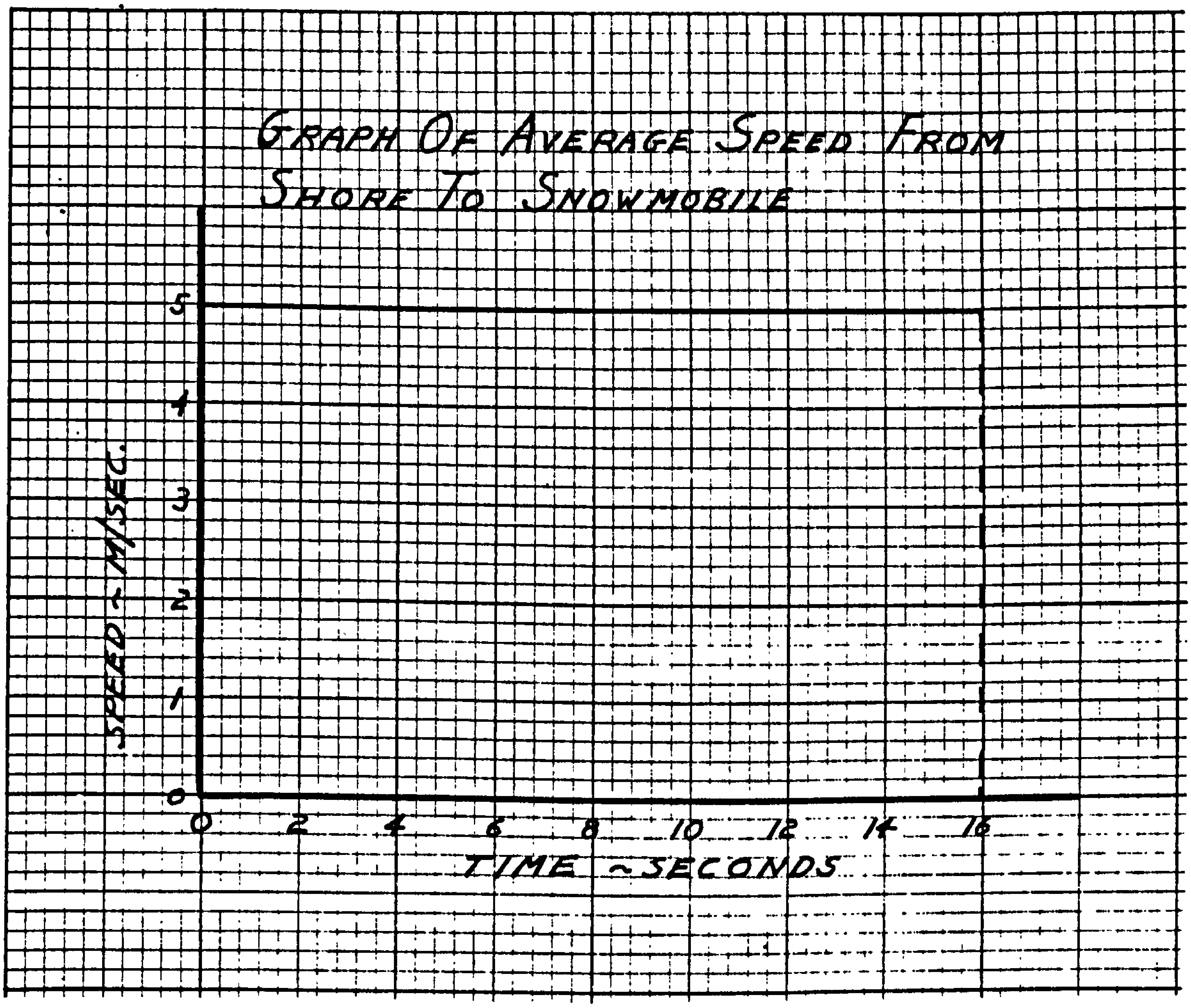
Speed

Now let us look at speed. Common units for reasoning speed are: feet per second (written ft./sec.), mi./hr., and km./sec. There are others. Speed is distance divided by time; $\frac{\text{distance}}{\text{time}}$. Suppose a skater wanted to go from the shore of a pond to a snowmobile near the centre of the pond as shown in the drawing below.



The shortest distance between the shore and the snowmobile is 80 metres. If the skater skates to the snowmobile in 16 seconds, what is his speed? If you said 5m/sec you would be giving his average speed. Average speed is the constant speed you would have to go to cover a specific distance in a certain time.

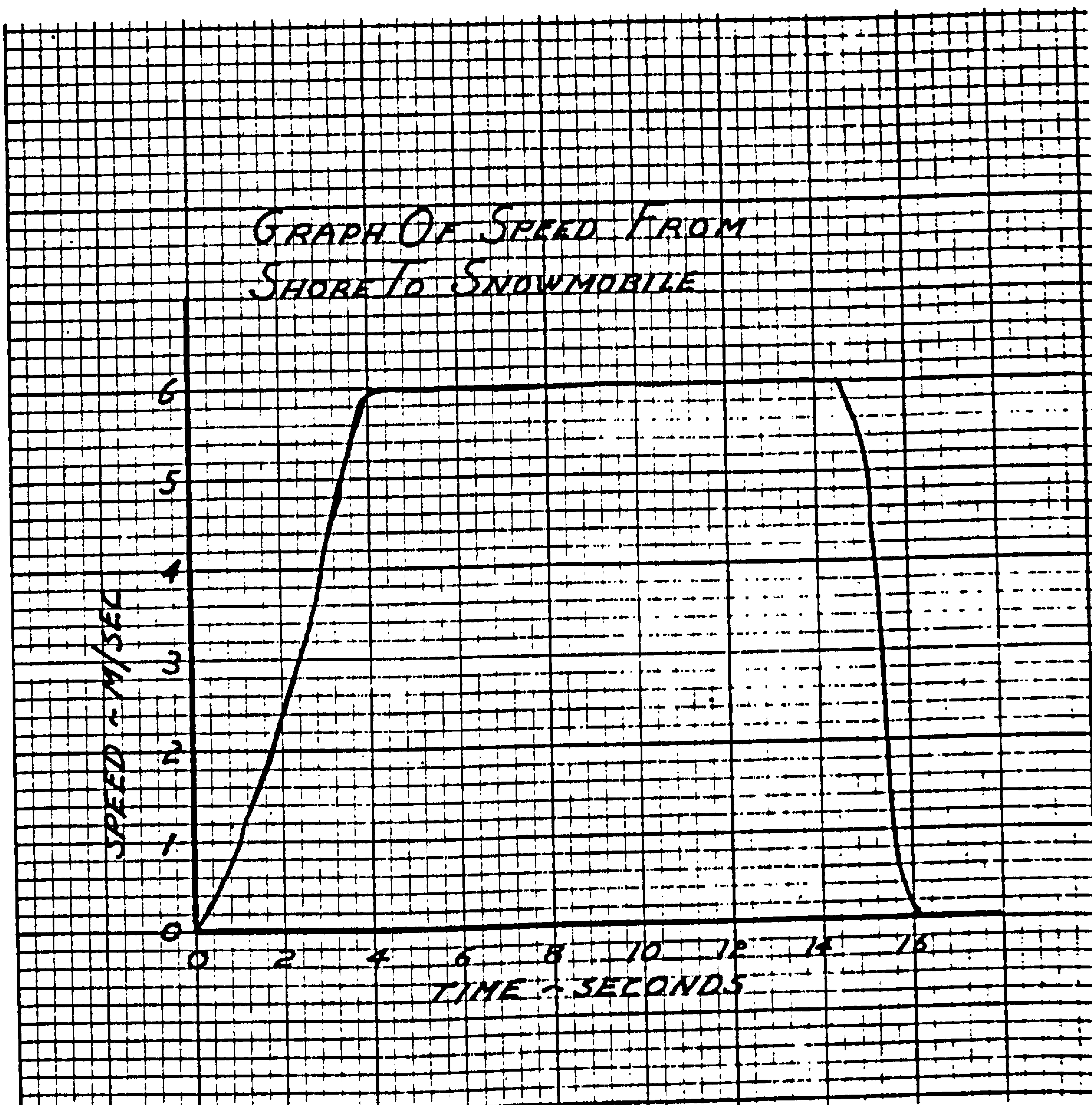
A useful way to study speed and other motion quantities is through the use of graphs. Below is a graph of speed vs time for the situation just described.



There are two important things to note about this graph. The first is that the average speed is represented by a straight horizontal line. Average speed is a constant speed, and the straight horizontal line shows that the speed is the same at all times between 0 and 16 seconds. The second thing to note is that the area under the graph is the distance (80 metres) to the snowmobile. The area under the line is the area of the rectangle shown. The area of a rectangle is base x height, in this case 16 sec. x $\frac{5m}{sec}$ = 80 sec x $\frac{m}{sec}$ = 80m. The area under any speed vs time graph is the distance covered.

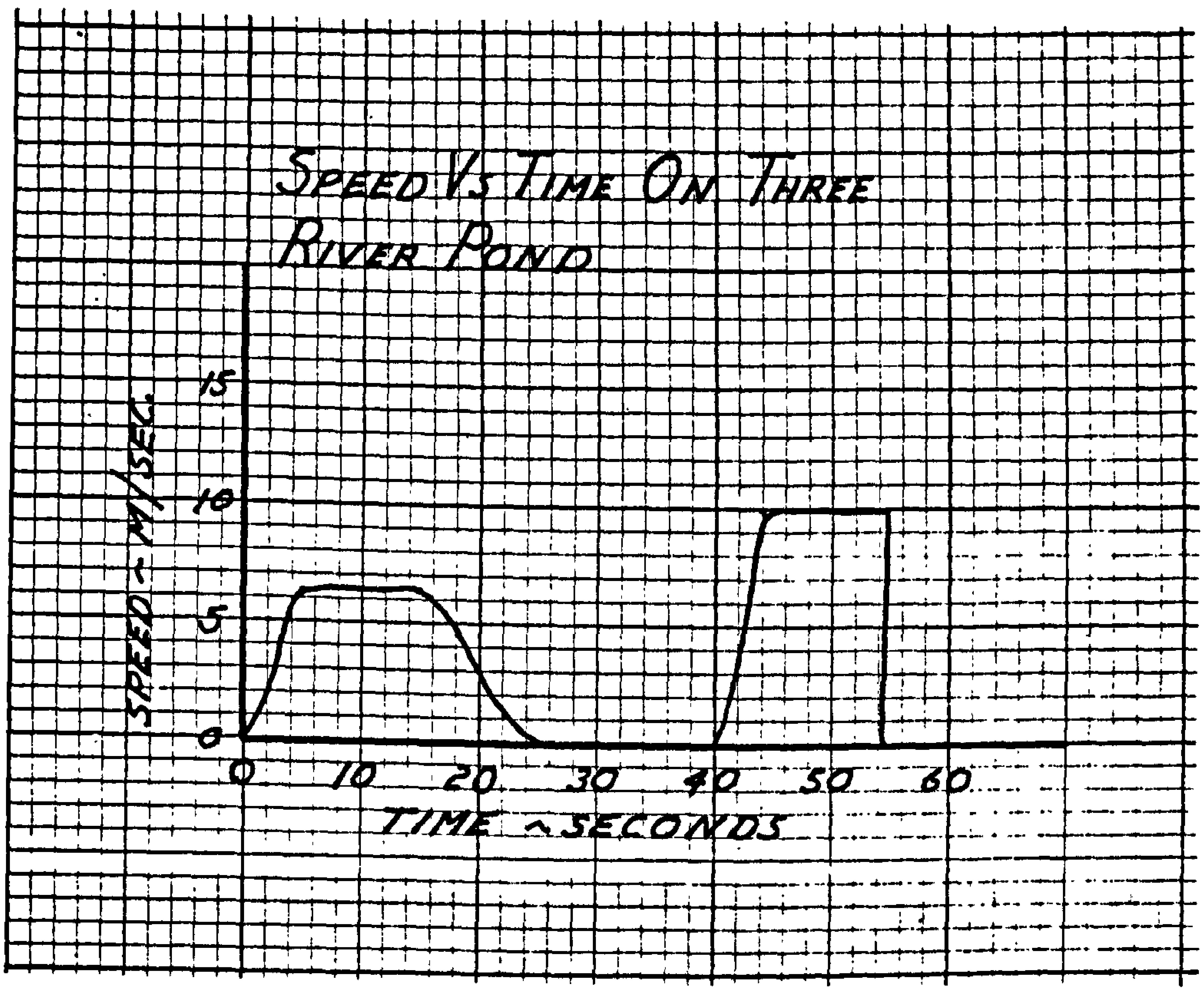
You know of course that the skater did not actually travel at a constant speed of 80m/sec from the shore to the snowmobile. He had to speed up in the beginning and slow down at the end. It is also unlikely that once he got going that he could keep his speed constant.

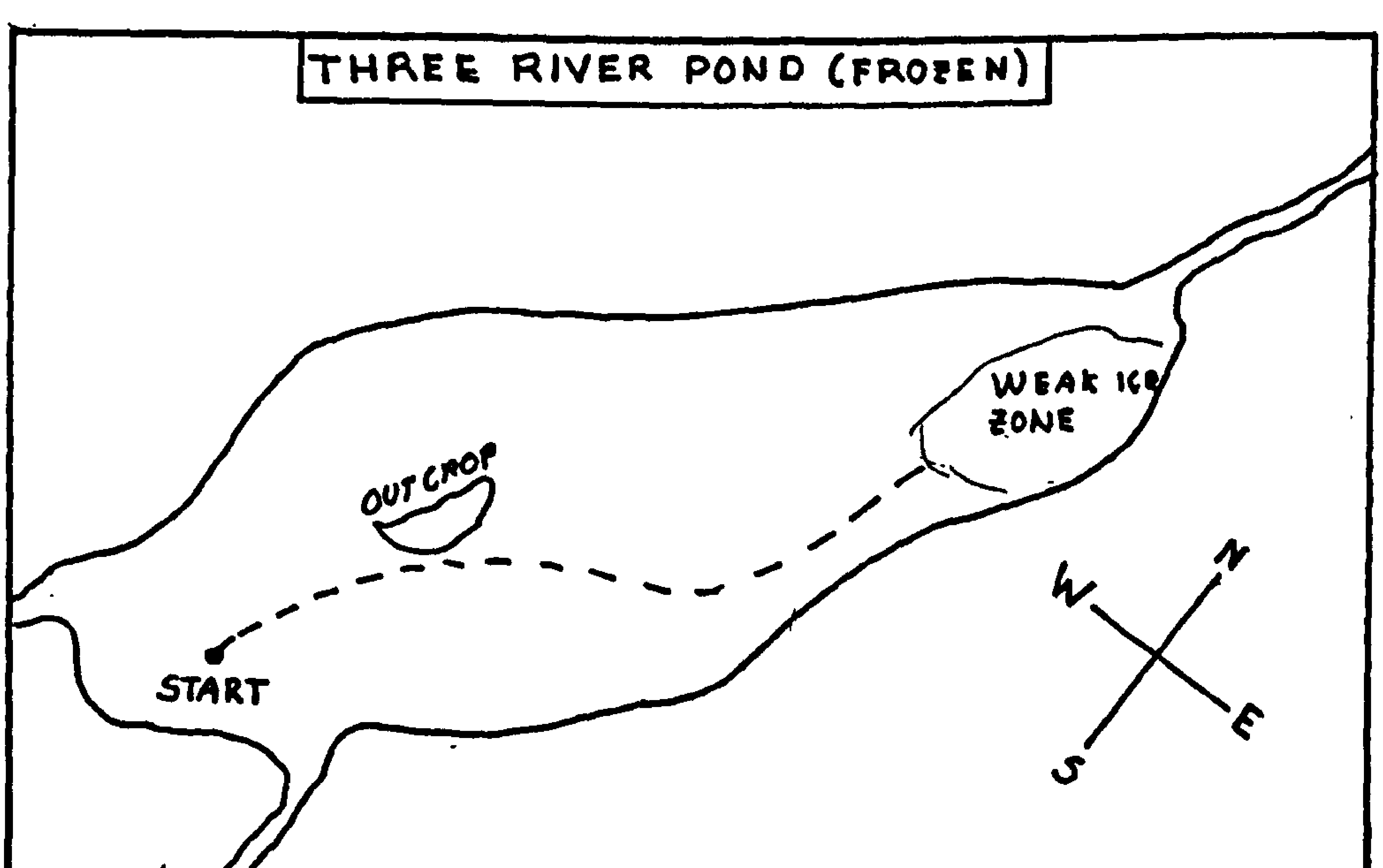
Below is a more likely graph of speed vs time in going from shore to snowmobile.



The area under this graph is still 80 metres although it is more difficult to calculate.

Below is a graph of the speed vs time of a skater on Three River Pond.





By looking at your graph, at the diagram of the pond, and considering what you have just learned , answer the following questions in your own words.

1. What did the skater do in the first 5 seconds?

2. About how far did he skate in the first 5 seconds?

3. What was his speed during the period, 5 seconds to 15 seconds?

4. About how far did he skate in the first 15 seconds? The first 25 seconds?

5. What did the skater do between 25 and 40 seconds?

6. About how far did the skater skate between the time period, 40 to 55 seconds?

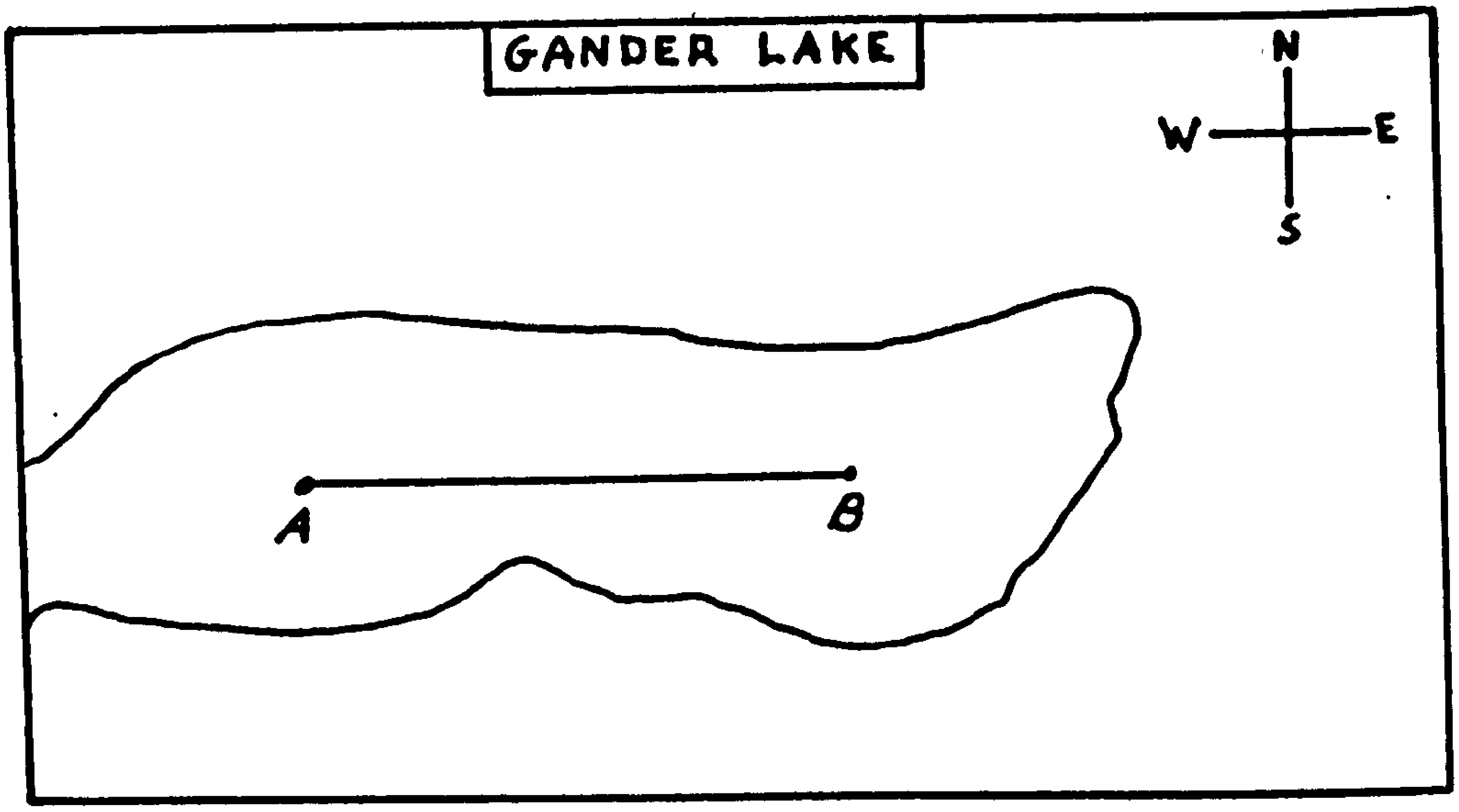
7. What do you think happened to the skater at 55 seconds?

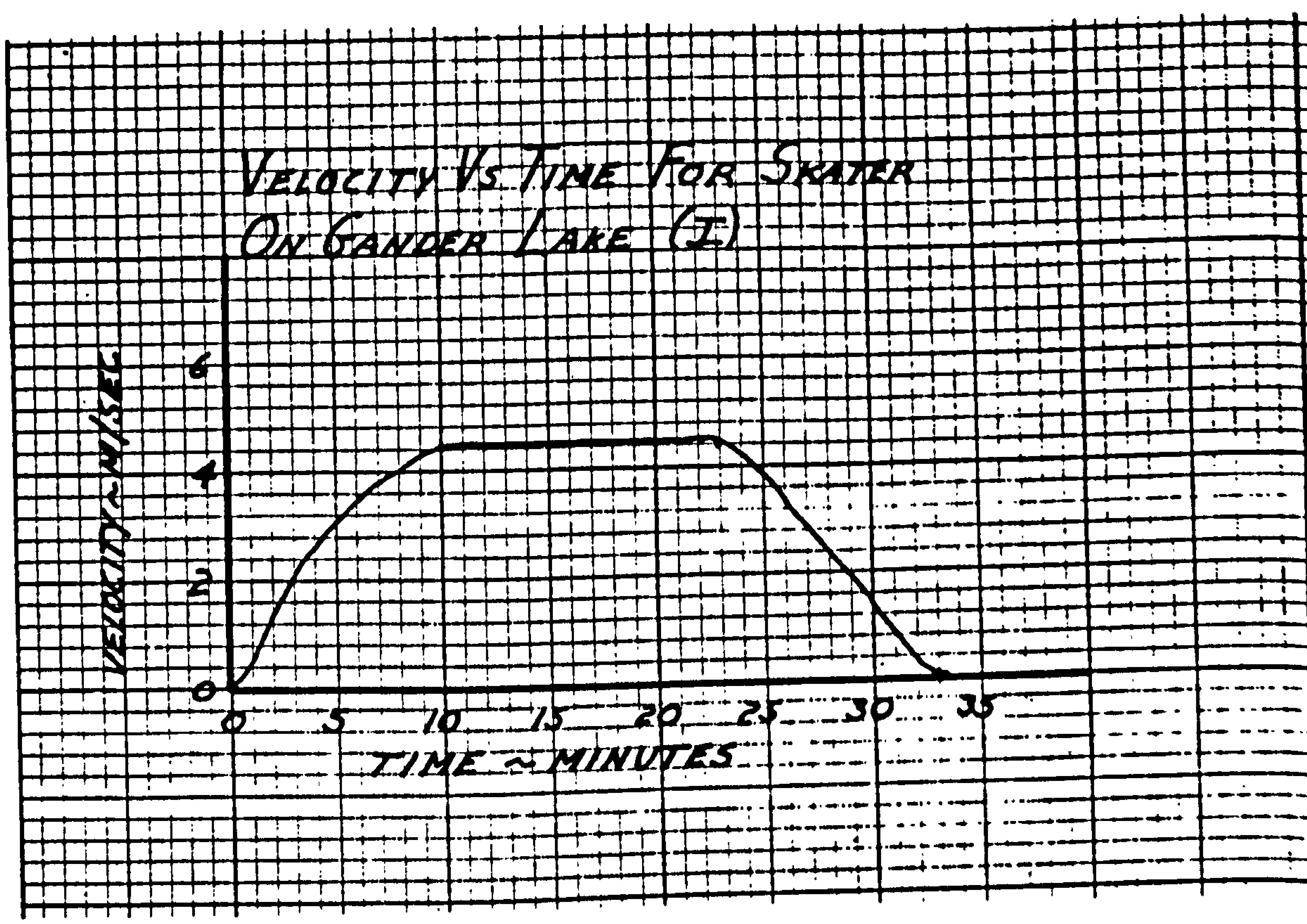
Velocity and Acceleration

So far in discussing motion we have looked at distance, time, direction, displacement, and speed. All of these help us describe motion. Yet there are a few more things that we should look at. Sometimes in describing motion it is useful to not only know the speed of a person at any time but also his direction as well. When we combine speed and direction we have what is called velocity. A skater may have a speed of 6 ft./sec., but a velocity of 6 ft./sec. in a direction 30° west of north, or a velocity of 6 ft./sec in a direction due east. His speed would be the same in all cases but his velocity would be different because he would be moving in different directions. Clearly velocity gives us more information than speed.

We can make velocity vs time graphs if the change in velocity is not too complicated. Usually this is done for an object that goes in one direction and may turn around and then go in the opposite direction.

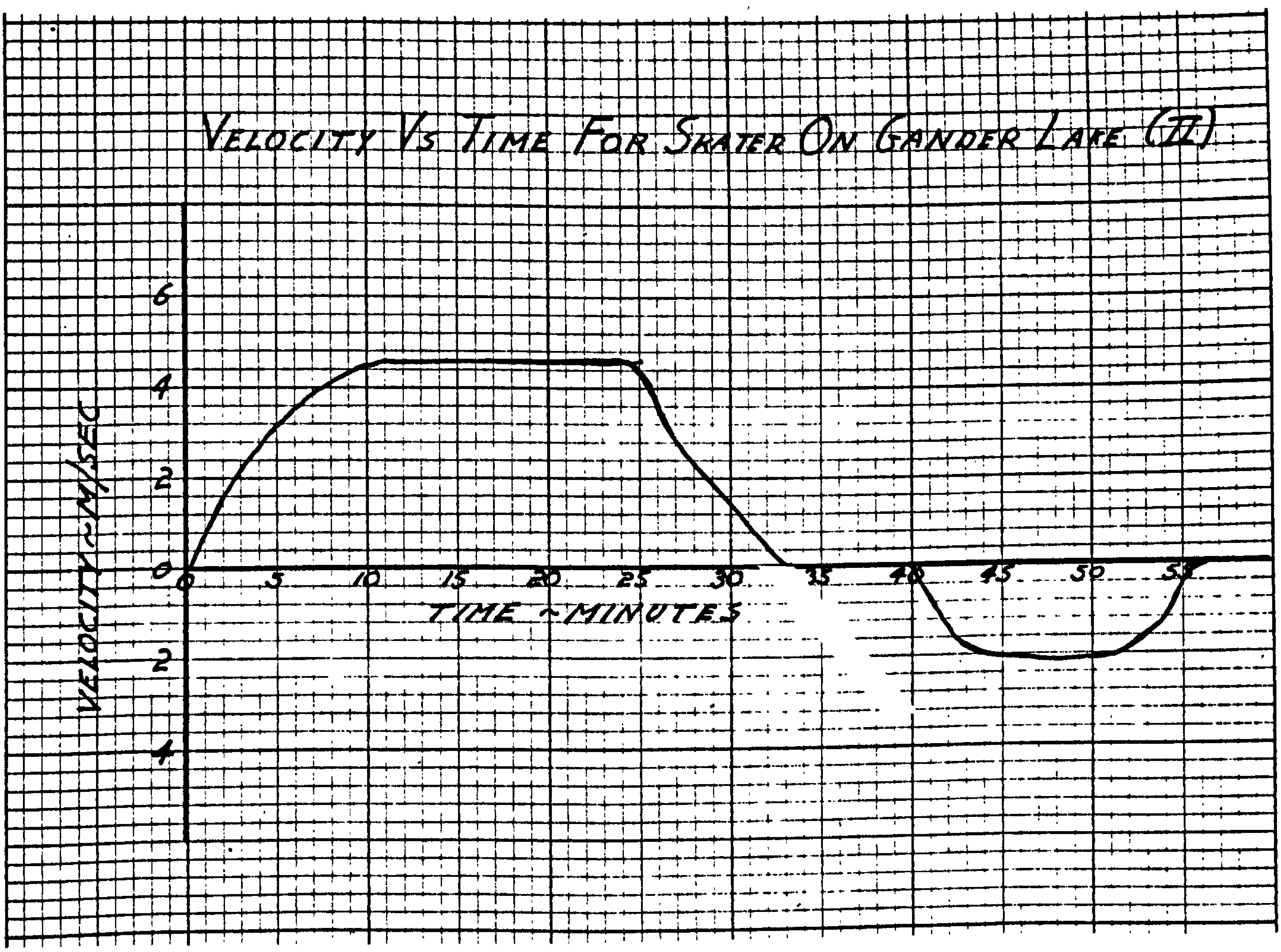
Below is a velocity vs time graph of a skater on Gander Lake.





The skater started at point A and took 33 minutes to skate to point B. He headed in an easterly direction throughout the entire 33 minutes. He began by slowly speeding up to 4½ m/sec. in about the first 10 minutes. He remained at this speed until about 23 minutes. Then from 23 minutes to 33 minutes he slowed down to a stop. At no time did he change direction.

The graph below is the same as the one above for the first 33 minutes, but it shows what the skater then did from 33 minutes to 56 minutes.



He remained stopped from 33 to 40 minutes. He then skated back towards point A between 45 and 60 minutes. Was he able to get back to point A by the time 60 minutes had elapsed?

We need to consider one other quantity in describing motion. This is acceleration. Acceleration is defined as the change in velocity during a certain period of time, or the time rate of change of velocity. It has units such as metres per second per second, $\left(\frac{\text{M./sec.}}{\text{sec}}\right)$, or metres per second per minute, $\left(\frac{\text{M./sec.}}{\text{min.}}\right)$.

Because it is a change in velocity, there are three ways in which it can come about. It can come about by a change in speed only, a change in direction only or both a change in speed and direction. Remember velocity is both speed and direction so if either speed or direction changes we must have a change in velocity, and therefore an acceleration. The skater on Gander Lake changed the speed part of his velocity during about the first 10 minutes. Therefore he was accelerating, and in this case we say he was "speeding up". From 10 minutes to about 23 minutes he changed neither his speed or direction so his velocity did not change. It remained at about $4\frac{1}{2}$ m./sec. eastward. His acceleration was zero. From about 25 minutes to 33 minutes he slowed down, therefore he accelerated. Sometimes this kind of acceleration in which a person slows down is called deceleration. From 33 minutes to 40 minutes his speed was zero and we cannot say that he had a direction. Therefore his velocity was not changing and his acceleration was zero. From 40 minutes to 43 minutes he was "speeding up" in the westward direction, and therefore accelerating. What was his acceleration from 43 minutes to 50 minutes? Was he accelerating from 50 minutes to 56 minutes?

Activities on the Ice

Earlier in this section you examined rather closely different properties of motion on the ice such as time, displacement, velocity and acceleration. You did this in class with paper and pencil through the use of graphs and specific examples.

Now it is time to actually go out on the ice and conduct some measurements related to motion on those of you who will be skating. You will of course make use of much of what you have learned in the last section.

Three days will be devoted to "Activities on the Ice". During day 1 you will plan the activities and the measurements, day 2 will be spent on the ice itself and day 3 will be devoted to a post lab discussion of your measurements and results. Below is a brief outline of what might take place on each of the three days. The specific details are left for discussion with you and your teacher.

DAY 1 - PRE-LAB DISCUSSION.

a. What should be measured?

b. How should measurements be made?

c. What data should be collected?

d. What materials are needed?

e. How should students be divided into groups and what is the role of each student in the group?

f. In what order should measurements take place?

DAY 2 - EXPERIMENTS ON THE ICE

To be done on frozen pond.

DAY 3 - POST LAB DISCUSSION $\boxed{T_3}$

From the data you have collected during your experiments on the ice, each group should do the following:

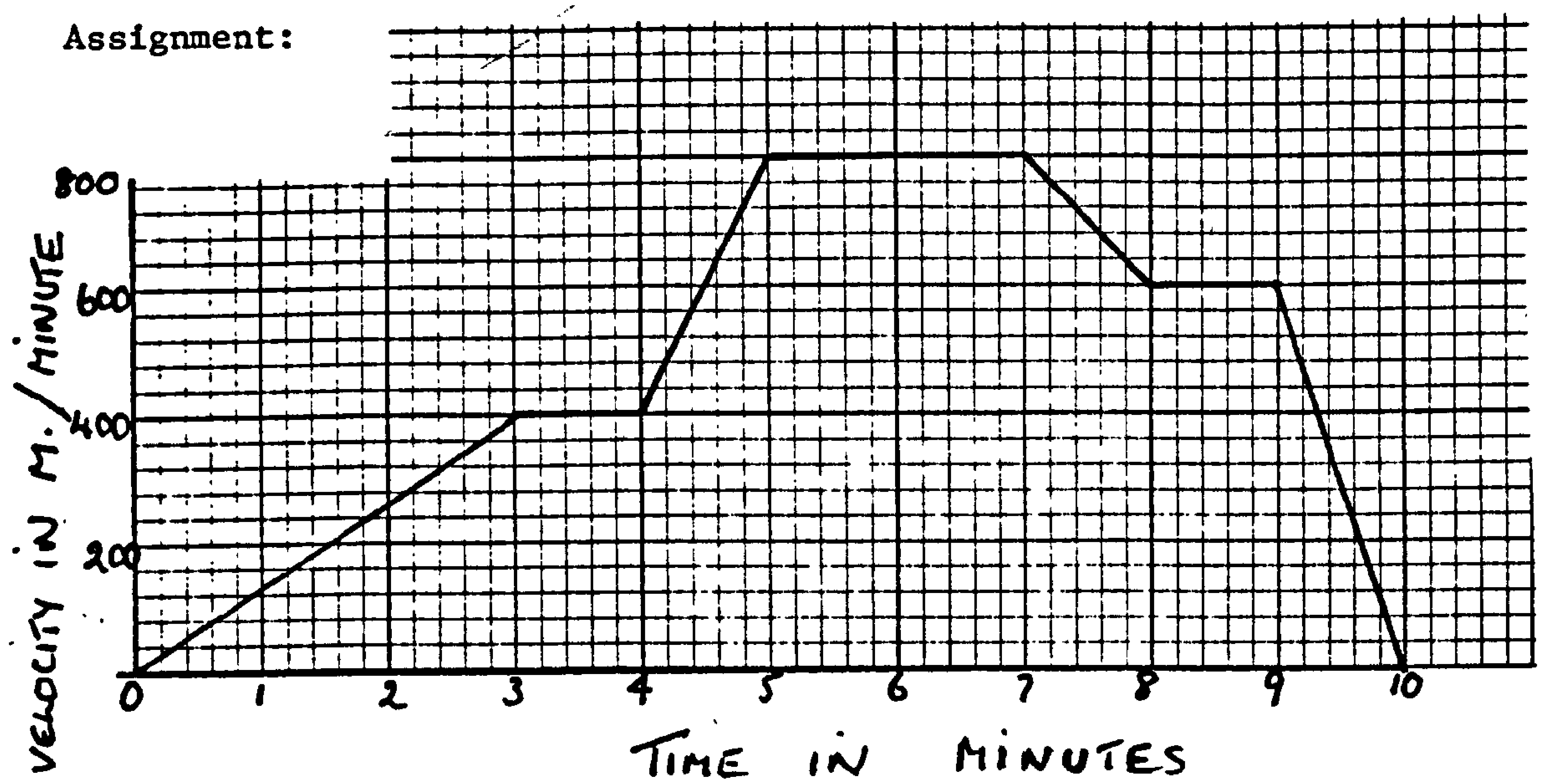
a) Make tables listing the data for each experiment.

b) Make a graph of displacement vs. time, average velocity vs. time, etc.

c) Discuss reasons for varying results among groups.

d) Discuss possible sources of errors in the experiments.

Assignment:



The above graph represents a journey undertaken by an ice-skater. Answer the following questions based on the graph.

a. What is the highest speed obtained?

b. In which portions of the journey does the skater accelerate?

c. In which portions of the journey does the skater deccelerate?

d. In which portions does the skater travel at a constant speed?

e. Roughly how far does the skater travel during his journey?

Project:

Consult a reference book such as the "Guiness Book of Records", and find the world speed skating records. Calculate the overall speeds for various distances. Find out how speed skates differ from other types of skates.

IV. ICE SPORTS

In this section we are going to investigate a number of factors associated with sport on ice. You will investigate the effect of practice on skills, test a model for forcasting hockey results, and consider the method of judging used in figure skating. You will no doubt think of other ideas associated with ice sports that you can investigate, and you will be given an opportunity to do so in your science class.

The Effect of Practice on Skills

Professional athletes spend many hours training for their occupation. (Indeed it is as well to remind ourselves that it is an occupation, not a leisure activity.) This training often involves exercises especially designed to improve speed, stamina and skill. Can we, in fact, really improve skills with practice? In this section we will investigate this question experimentally.

First we must select a skill to investigate. Most students will have spent some time scrimmaging with a hockey stick and a ball, and many will have developed considerable skills. For this investigation you will investigate the ability to hit a small target using a hockey stick and a ball. Remember the question we are investigating is, can we improve skills with practice?

In this type of experiment we usually divide the participants into two groups, one group who practise, these are the EXPERIMENTAL group and another group who will perform the task without practice. These are the CONTROL group. If you stop and think this is similar to the way many laboratory investigations are carried out, we often use a control. However one problem that we meet here is that our experiments involve humans, who have widely different abilities. Thus it would be no good to put all the accomplished hockey players in one group, and all the non experts in another. Why?

One solution could be to assign the students to groups by chance, we call this assigning at RANDOM. Can you think of a way to do this?

However since we have a small number of students with which to experiment we will use a different technique to assign students to either the EXPERIMENTAL or CONTROL group. Firstly we will have students use their weaker hands to shoot with. Thus if you normally shoot left handed, shoot right handed and vice-versa. Why do you think it is a good thing from the experimental point to view?

Arrange a small target at which to shoot, and agree on the distance from which to shoot at it. The task must not be too difficult or too easy. Now let each student who is to take part in the experiment have 10 shots at the target (Don't forget to use the weaker hand!). Record the number of successes for each student.

The students are now divided into two groups on the basis of their abilities in the skill under test. Separate the students into pairs with similar scores put one from each pair in the control group, and one in the experimental group. The two groups are now said to be MATCHED for the skill to be tested. So any results obtained in the experiment are due to the effect of practice. In this experiemnt practi e is the independent variable.

Having divided the subjects into two groups, we can now let the experimental group practise. Let each student in the experimental group take 50 shots as a practice. The control group should take 50 shots without the ball. Why?

Now let all the subjects take 10 shots at the target. Record the results in a table below. With the results for the control group in one column and the experimental group in the other.

What conclusions can you draw from the totals for the two groups? Is the difference big enough for you to make a definite decision? Would it have been better to increase the number of subjects?

For us to give definite answers to the questions above we would have to use the subject called STATISTICS. A number of tests have been developed by statisticians which enable us to decide whether results obtained in experiments are simply due to chance, or whether they have been caused by an experimental factor. These tests are too complicated for us to use here, and so we will simply use the totals as a basis of answering the question.

Assignment:

In the exercise above you investigated the effect of practice on a skill. Design an experiment to investigate the question, does fatigue affect the performance of a skill? (Use a different skill, if you want to). If there is time your teacher may let you perform the experiment as a class. If you do the experiment examine the results, and decide what importance they may have for the coach of a team.

Observing a Game

Modern hockey places great emphasis on fitness and checking and nearly every coach wants a two-way hockey player. When we watch a game we often get a false impression of who works hard and who does not. Naturally we follow the puck, where the immediate action is, and often we neglect to observe the rest of the ice. We may be impressed by a fancy play of a centre, and yet not be aware of the hard work of a winger in support. Generally when we observe a game we do so for enjoyment and often our emotions cloud our judgment of what goes on. Thus we often yell and complain when our favorite player is knocked over, even though it may be a legitimate check. In science, we cannot afford to make poor, erratic observations, we must make SYSTEMATIC observations. By this we mean that our observations must be planned and made according to a system or pattern. Most professional coaches have developed techniques for making systematic observations of games, and in this exercise you will make a systematic observation of a game. Afterwards you can use your data to analyse the game, and answer a number of questions.

Divide the class into two groups, observers and players. The players will engage in a hockey game for 15 minutes, either on the ice, if it is available, or floor hockey. It will be easier if you use only twelve players, six a side, during the short game to simplify the observation process.

Each observer should be assigned a player to observe, and should prepare three plans of the rink drawn to scale on graph paper. These plans should be as large as possible.

When the game starts the observer is to record the position of the player, on the plan of the rink, at 15 second intervals. In addition to marking the position, if the player is carrying the puck mark the point with a p, and if he is checking mark it with a c. Each time he records a position he is to connect it to the previous one by a straight line. The game will be divided into three five minute periods, and the observer should use one plan for each period.

From the class data answer the following questions.

1. Who works the hardest during the game?

2. Who carried the puck the most?

3. Who checked the most?

4. On the average do forwards work more or less than defencemen?

5. Do the forwards come back and help the defence?

The method of systematic observation can be used to study other aspects of the game, e.g. you could compare the styles of two teams. Thus do Philadelphia really check more than Boston or Montreal? Or is Montreal a play making team? You simply have to decide what aspect of the game you will observe before you start to record your observations. Some of you may think of other hypotheses you can test, or you can apply the technique to a full-scale hockey game.

How good a Judge are you?

In the last exercise you developed a method for making systematic observations of a hockey game. From these observations you were able to make an analysis of the game and make OBJECTIVE judgements about how players performed. One area of ice-sports that has received a great deal of criticism is figure skating. In the world and olympic championships there are often arguments about the system of deciding the winner. In a hockey game there is usually no argu ment about who wins, it is simply the team with the most goals. However in figure skating there is not such a straight forward method of deciding the winner. Similarly in most areas of science it is possible to make a definite measurement. Thus if we are studying how fast a plant grows, we can measure the height of the plant, and the length of time it has been growing. However in some areas of science, such as psychology which deal with behaviour, such precise measurements are not possible. We find the same problem in marking an essay or a poem, we cannot be as precise or objective about it as we might be in marking a mathematics problem.

Ideally, it would be helpful if you have a couple of figure skaters in the class. However it will probably be simpler to find a number of people who can perform a simple physical exercise such as a cartwheel or a handstand. These students will act as our competitors. The rest of the class will act as judges. Have the competitors perform their tricks, they should all give the same performance. After each performer has finished, the judges should give each performer a mark out of 10. When all the performers have finished tabulate all the data, and note for each performer the distribution of the marks. Thus note how many students gave him 1, how many 2, etc. For each performer note the RANGE of their marks.

Now you will probably find that each performers marks vary considerably. This is not really surprising. Why?

To develop a more OBJECTIVE method of marking we must agree on what constitutes a good cartwheel, or handstand, or in the case of a figure skater a good jump. So your teacher will help you to analyse the various steps in the performance, so that you can all agree on what a good handstand, etc., should include. Having agreed on this we can now develop a more accurate marking scheme. You may want to assign marks for each part of the performance. When you have developed your marking scheme, have the performers repeat their tasks, and mark them again. Record the data as before, do the marks have a broader or narrower range than before?

Even with behaviors that we cannot measure directly, we can make our measurements more accurate. In figure skating there are usually a number of judges instead of just one judge. Why is this?

One solution to some of the controversy that surrounds figure skating would be to make it non-competitive. In the early olympics certain sports were non-competitive, there were no winners. Many people feel that we are too competitive in nature, and many of the problems in sports arise from this. What do you think? Maybe you can have a class discussion on the topic.

Testing a Model

In this short exercise we will try to forecast the results of some hockey games, and in doings so we will use a method of investigation often used by scientists. Let us suppose that we are trying to develop a system of predicting hockey results. After some preliminary observations we decide that forecasting the results is really a matter of pure chance. Further we propose that in NHL games, for every one tied game, there are two wins by teams on the road, and three wins by home teams.

Since our model suggests that predicting the results is a chance thing we can use a dice numbered 1 to 6. Let 1, 2, 3, represent a home win, 4 and 5 a win on the road, and 6 a tie. Obtain the list of fixtures in the paper, Saturday and Sunday are best since there is usually a large number of games. Predict the results using a dice. You may wish to set up a slightly different model for WHA games, since this league does not have tied games. Note it below.

Now let us test our model against another method. Choose from the class a panel of "experts" who will predict the results based on their knowledge. Record both sets of predictions below.

When the games have been played check the results. Which method was the most successful?

Could you suggest a change in your model to improve it?

In this somewhat light-hearted exercise we have used an important pattern of investigation often used by scientists.

a. Propose a theory or model.

b. Use it to make predictions.

c. Test the predictions experimentally.

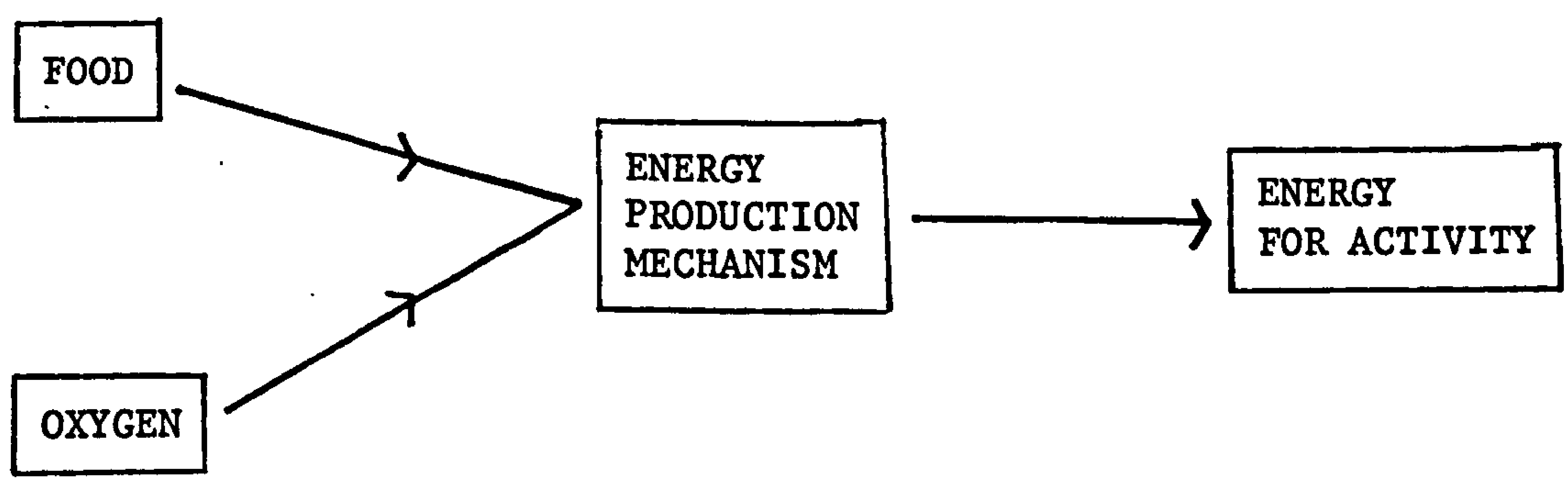
d. Alter the model if necessary, and retest it.

The important difference between a scientific theory or model and a non-scientific theory or model is that the former will enable us to make predictions. These predictions should enable us to support or reject our theory depending on how they stand up to experimental investigation.

V. ENERGY AND SKATING

So far we have considered how the body moves and the forces that are involved in the activity of skating. In this section we will consider some aspects of the manner in which the body obtains the energy needed for skating.

The body obtains its energy through an involved process we call Respiration. We can represent the stages in respiration below.

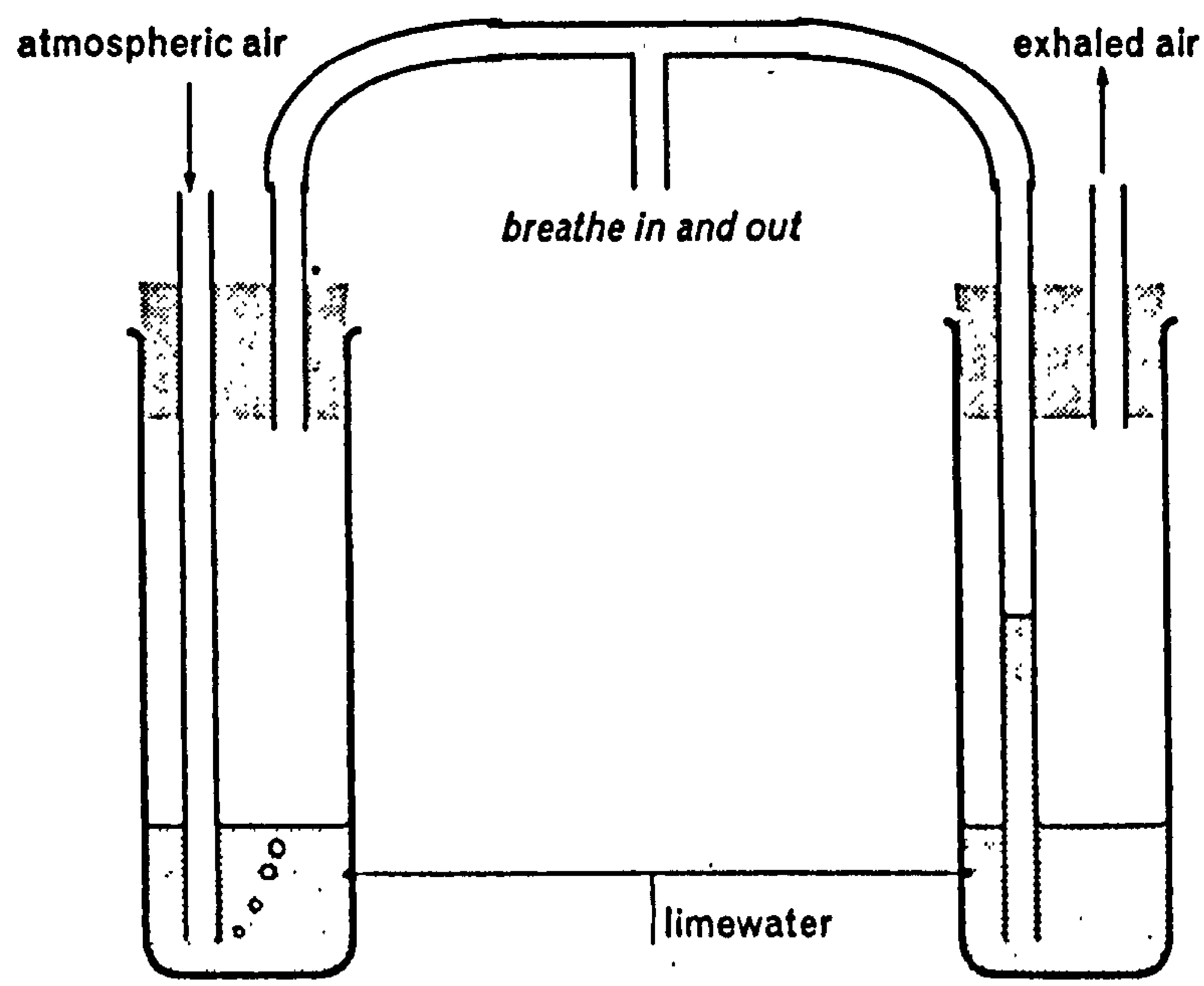


Breathe In, Breathe Out

Although not all organisms need oxygen for the process of respiration humans and many other types of animals do. Most of you will know already that man takes in his oxygen via his lungs, a process often referred to as external respiration. In his lungs the oxygen is absorbed into the blood stream and a waste product carbon dioxide is removed from the blood, and expelled from the lungs.

If you blow through a straw into a solution of limewater you will observe that it turns milky, an indication carbon dioxide is present. This is often cited as proof that carbon dioxide is produced during respiration. However, this is an unwarranted conclusion on the basis of this experiment. Explain why.

The apparatus shown below is an improvement on the simple exercise described above. Explain why.



Thus we can summarize this process of external respiration as oxygen taken in and carbon dioxide given out. What effect does such an activity as skating or any other energetic pursuit have on this process?

Choose a partner and have him sit quietly for a few minutes, then count how many breaths he takes in a minute. Now have him undergo some moderate exercise for a minute, e.g., if possible skate at medium speed over an agreed distance. Then again count the breathing rate. Record your observations.

How long does it take for the breathing rate to return to normal?

Now have your partner engage in some vigorous exercise, e.g., skate or run at top speed for one minute. Again measure the rate of breathing, and observe how long it takes for the breathing rate to return to normal.

What do you notice about the depth of breathing after exercise?

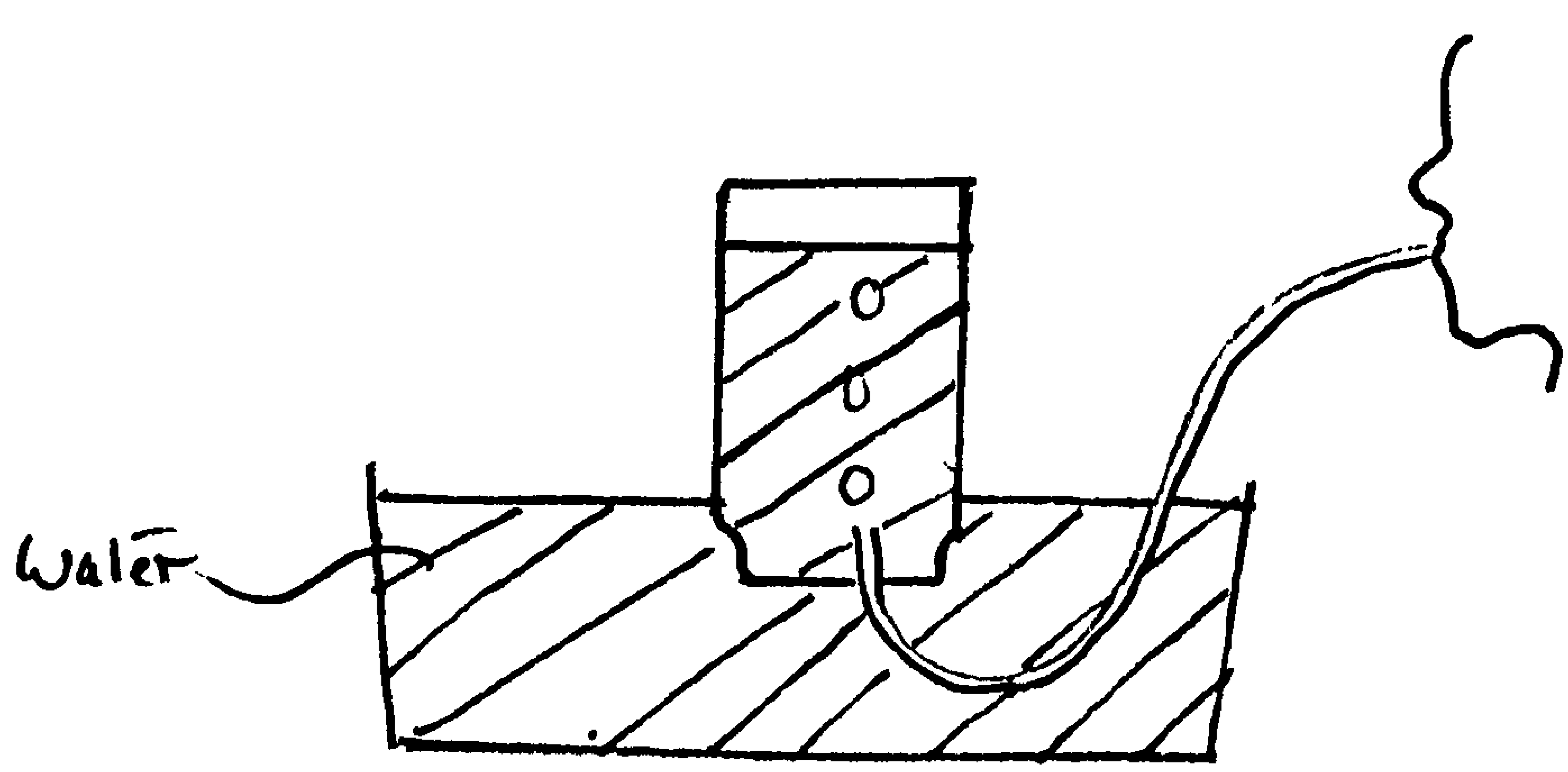
We can see that exercise has a considerable influence on the action of breathing. Let us now see if we can detect any change in the respiratory gases involved. To try to detect any change in the gas exchange process with exercise we could either consider oxygen which is taken in, or carbon dioxide which is given out. In this next activity you will consider the amount of oxygen in expelled air.

Since the % oxygen that we take in is a constant, 20.9%, the amount of oxygen in expelled air will indicate indirectly how much is absorved.

Thus if on the average there is 16.4% of oxygen in expelled air, how much oxygen will the average person absorb

What factors do you think might affect this figure?

To determine the % of oxygen in an air sample is not easy and requires quite sophisticated apparatus. However, we can obtain an indication of how much oxygen there is in a sample of a gas by measuring how long it can support combusion. We can collect samples of gas from our lungs as shown below.



Collect three containers full of air expelled from your lungs, using the arrangement shown.

The first after you have been sitting still for one minute.

The second after you have been engaged in moderate skating for one minute.

The third after you have been engaged in strenuous skating for one minute

In each case time carefully how long each will support the burning of a candle.

Container	Condition	Time necessary to extinguish candle
1	after sitting	
2	after moderate skating	
3	after vigorous exercise	
4	ordinary air	

Also include a fourth container including air which has not come from the lungs.

From the table above answer the following questions.

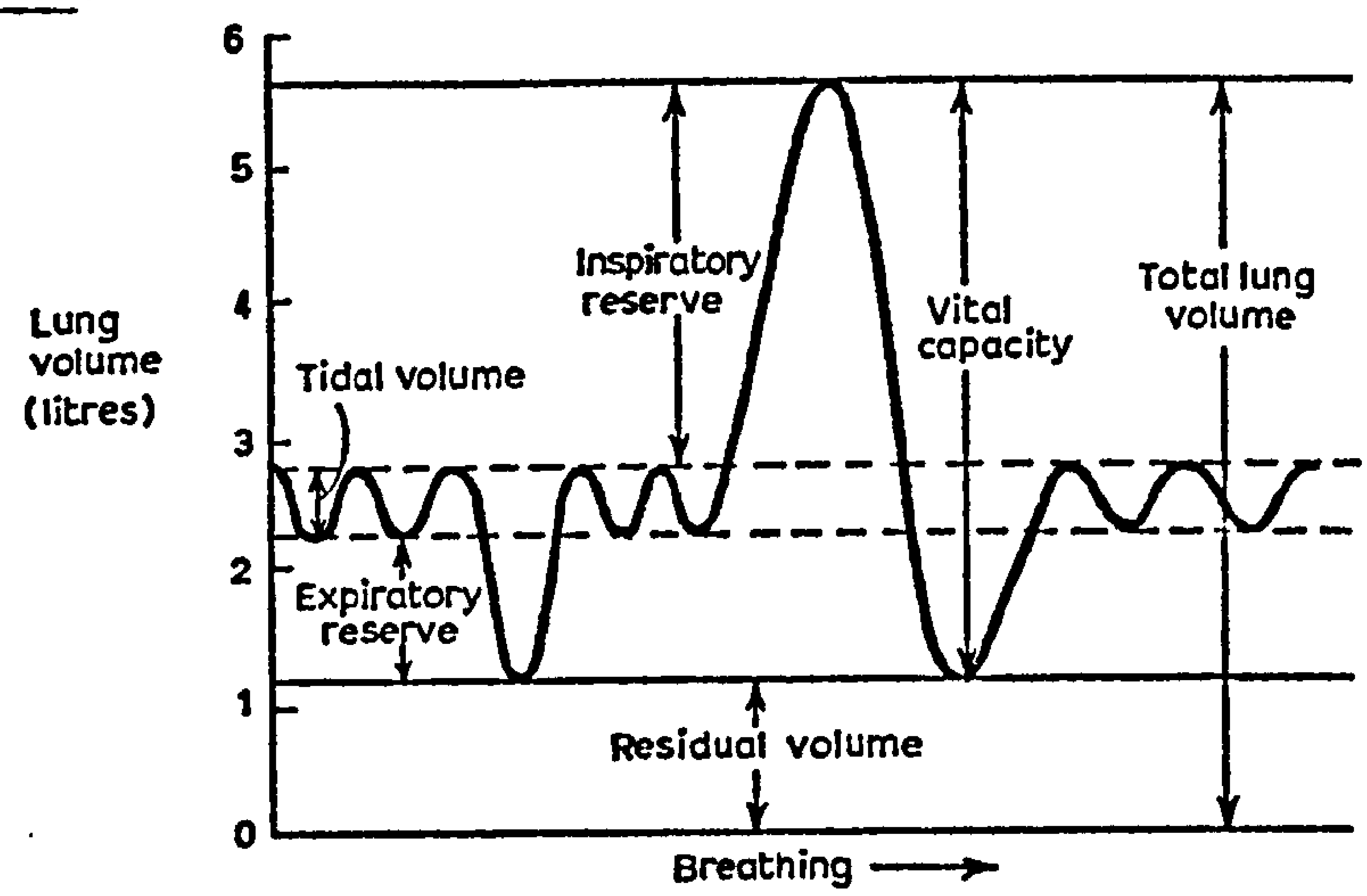
1. Which container supported the burning of a candle the longest?

2. What does this show?

3. What observation can we make about the effect of exercise on the amount of oxygen absorbed from air taken into the lungs?

This experiment makes several assumptions which might affect the conclusions one can draw from the results. What are these assumptions?

Assignment:



The graph above shows the volume of air contained in the lungs during various types of breathing.

1. The TIDAL VOLUME is the volume of air breathed in and out while at rest. From the graph how much air is it?

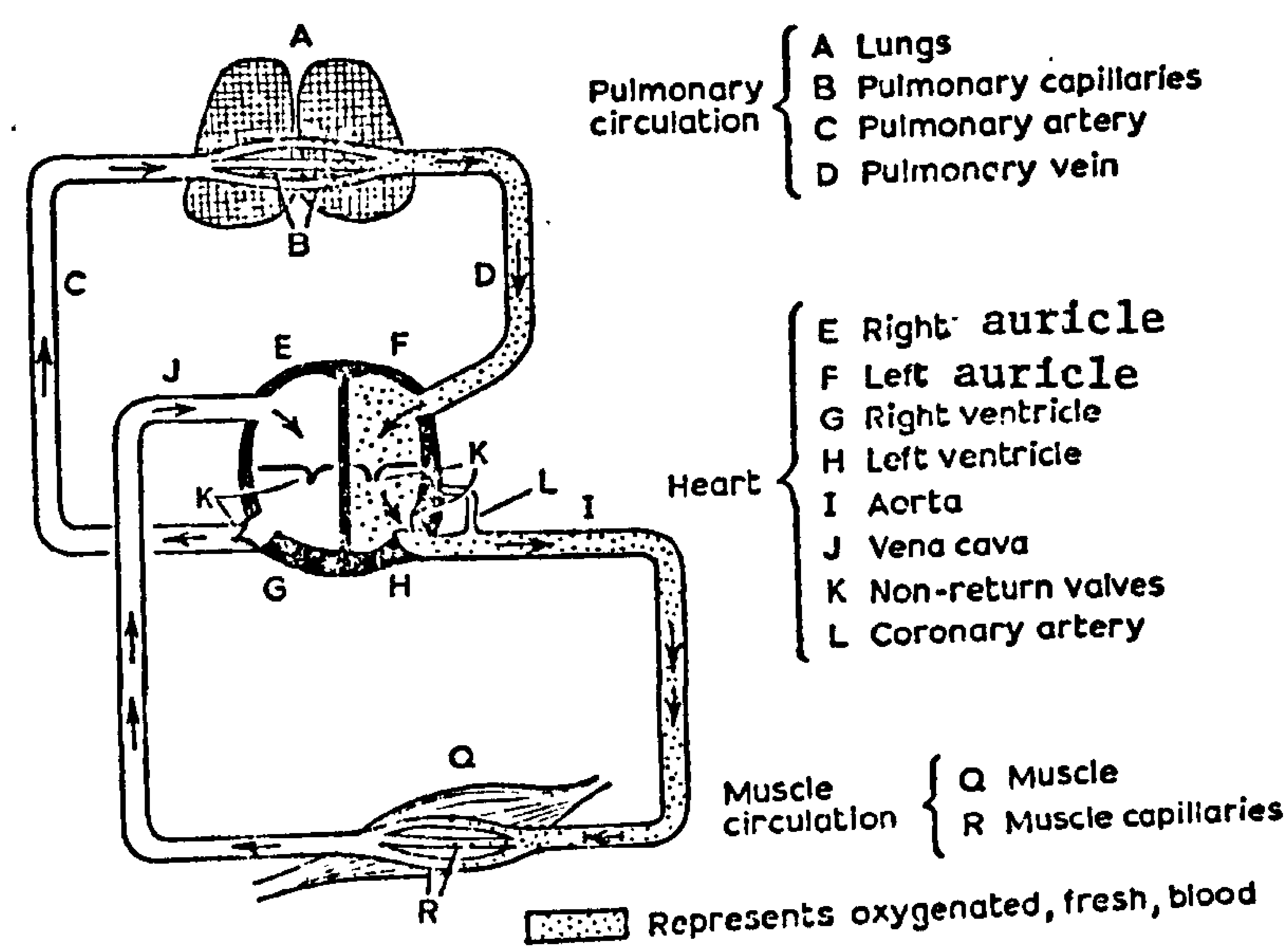
2. The EXPIRATORY RESERVE VOLUME is the volume of air that would be exhaled if you were to breathe out as hard as possible. How much air is this?

3. RESIDUAL VOLUME is the amount of air left in the lungs, which cannot be forced out. How much is it?

4. INSPIRATORY RESERVE VOLUME is the amount of air above normal resting volume which it is possible to breathe in. In some athletes this can be as much as 5 litres, in this case how much is it?

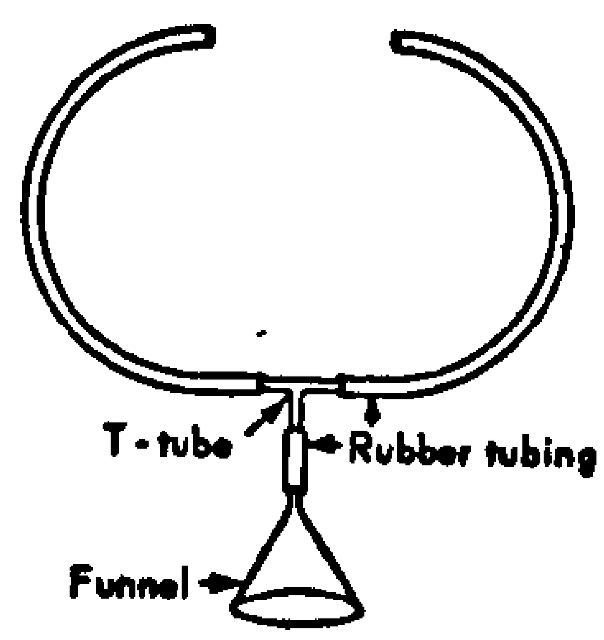
The Heart

In the last section we investigated the effect of exercise on the amount of oxygen absorbed during exercise. The oxygen that is absorbed by the lungs is carried around the body by the blood which circulates through a network of tubes. The heart acts as a pump for this circulation system. Basically the heart consists of four chambers, the AURICLES which receive the blood, and VENTRICLES which pump the blood.



The left side of the heart is more muscular than the right since it receives blood from the lungs and then has to pump it around the body. While the right side simply receives the blood and pumps it to the lungs. The heart cycle consists of the auricles contracting so that the blood is pumped into the ventricles, then the ventricles contract to force the blood through the system, and finally both the auricles and ventricles relax and refill with blood. The sudden rise in pressure as the ventricles contract is what we feel when we take a pulse.

You can make a stethescope with which to listen to the heart-cycle. Construct the apparatus below from, a small funnel, rubber tubing, and a T-juntion.



Hold the funnel over your heart, while your partner listens by holding the ends of the rubber tubes in his ears. Describe the rhythm you hear.

During physical activity more oxygen is required by the muscles. Consequently the heart has to pump more blood around the body. In this next exercise you will investigate the effect of activity on heart rate. However, first you must learn how to count the pulse. Take turns with a partner, grasp his wrist with two fingers on the wrist and apply slight pressure with thumb against the back of the wrist. Count the number of pulse beats in 15 seconds, and calculate the rate per minute.

When you have mastered the technique, divide into groups of four. One student will serve as the athlete, one will take the pulse, one will act as a timer and one student will record the results.

Count the athletes pulse rate while he is resting, and record the data below. Then have the athlete perform some strenuous activity for several minutes, such as skating, or running, or skipping. Immediately the athlete stops his activity count his pulse rate for 15 seconds. Repeat this count at one minute intervals for 15 minutes. Plot a graph of pulse rate against time showing how the athlete recovered from his exertion.

Today considerable importance is attached to exercise and the effect it can have on the heart. Below is a table showing the heart rates at rest of different sportsmen.

Average Man	72	Sprinter	57
Weightlifter	66	Footballer	55
Volleyballer	60	Runner (Long distance)	35
Hockey Player	56	Rower	50

It is reasonable to assume that at rest all the above people will use about the same amount of oxygen. The difference in heart rates is due to the fact that an athletes heart can pump a greater volume of blood on each beat, this is probably due to stronger heart muscles.

A second effect of exercise is to improve the blood supply to the muscles of the heart. An athlete's heart has a larger system of circulation than an untrained heart.

The diagram below shows small sections of the hearts blood supply. Imagine a blood clot (Thrombosis) to form at point A in each case. What would be the effect on each person.

UNTRAINED HEART

TRAINED HEART

Providing the heart is normal, a gradual programme of exercise improves the health of the heart.

Food, our fuel!

Oxygen is only one essential for man in the energy producing process of respiration. Man also needs food, it is as much a fuel for our bodies as oil is for a furnace.

Just as different fuels can give out different amounts of heat, then foods have different energy potentials. In order to compare foods for fuel we need a unit in which to measure energy. Since the ultimate product of any fuel is heat, scientists compare foods in terms of a unit of heat, the calorie. The basic unit of heat is the calorie which is the amount of heat necessary to raise 1 m.l. of water 1°C.

Thus 100 calories would raise 1 m.l. of water 100°C or 10 m.l. of water 10°C or 100 m.l. of water 1°C. Because of the large energy potential of foods, nutritionists generally measure the energy of food in kilocalories.

1 kilocalorie = 1000 calories

One kilocalorie or Calorie is the unit that we use in discussing the energy potential of foods. Below is a list of common foods, and the amount of available energy they possess for one ounce of the food.

FOOD	ENERGY - K.CAL/Gram
Butter	7.9
Margarine	7.9
Milk, Fresh	0.7
Milk, Evaporated	1.6
Eggs	1.6
Chicken	1.4
Pork	4.2
Cabbage	0.3
Carrot	0.3
Potatoe	0.9
Turnip	0.2

FOOD	ENERGY - K.CAL/ Gram
Bread	2.5
Bacon	4.2
French Fries	2.5
Apple	0.4
Banana	0.8
Orange	0.4

Your normal energy requirements depend on a number of factors. Indicate some of the factors below which might have an effect.

It is estimated that on the average the daily energy requirements for school children are as follows:

	MALES	FEMALES
11-14 yrs.	2750 K/Cal	2750 /Kcal
15-19 yrs.	3500 K/Cal	2500 /Kcal

Think back over your own energy intake in a day. Try to estimate its calorific value. Record it below

One of the factors that affect the energy requirements of the body is physical activity. One would expect that a professional athlete might consume very large amounts of food. The table below shows how much energy is required for a physical activity.

ACTIVITY	K. CALORIES/HOUR REQUIRED
Sitting	100
Walking	300
Running	635
Skating	600
Dancing	420
Swimming	700
Tennis	425

Calculate from the information provided how much of different types of foods you need to engage in one of the activities above.

The majority of Canadians exceed considerably their energy needs. As a result many Canadians are overweight. Find out what you can about the diet of professional athletes. What sort of foods they include in,or exclude from their diet. By how much does their intake exceed yours?

Energy Production

So far we have looked at the two ingredients of energy production, oxygen and food. However, the mechanism of energy production presents some problems. Consider some of the following

I. Where in the body does it take place?

II. How does it take place?

III. In what form is the energy produced?

IV. How can an athlete draw on large amounts of energy for instant action?

The production of energy in the body takes place in small units called MITOCHONDRIA which are found in the cells of the body. However the process by which the energy is produced is far too complex to be studied here. It is sufficient at this stage to note that the process takes place in a sequence of steps, in which food, usually sugars or fats, are converted into energy for use by the body.

Let us consider the burning of a candle, we can see there are many parallels with the process of respiration.

$$\text{CANDLE WAX} + \text{OXYGEN} \longrightarrow \text{CARBON DIOXIDE} + \text{WATER} + \text{ENERGY AS HEAT AND LIGHT}$$

$$\text{FOOD} + \text{OXYGEN} \longrightarrow \underbrace{\text{CARBON DIOXIDE} + \text{WATER}}_{\text{EXPELLED AS WASTE PRODUCTS.}} + \text{ENERGY AS ?}$$

However unlike the candle, man does not immediately produce his energy as heat. After all you do not suddenly get hotter after eating breakfast, although certainly some of the energy is used in maintaining body temperature.

The energy produced by the process of respiration is stored in a chemical compound called Adenosine Triphosphate or A.T.P. This can be regarded as energy currency which can be 'spent' anytime the body requires energy for work. Thus each time a skater exerts his muscles, the energy needed to make the muscle contract is supplied by the energy currency A.T.P., which is the end product of the process of respiration. When the energy stored in A.T.P. is used by a muscle the A.T.P. is then broken down and the products are recycled into the process of respiration.

We have seen that oxygen is used in respiration, however, the energy producing process of respiration can function for a short period of time without oxygen.

Try skating a short distance; 30-40 metres, at top speed, count how many breaths you take as you skate. (You should have done this already at the beginning of the module).

We can make use of this ability to produce energy without oxygen, only for a short period of time, because without oxygen, a chemical called lactic acid accumulates in the muscles, which causes them to feel tired and sore.

A hockey player played a vigorous shift which lasted three minutes, the amount of lactic acid in his blood was measured at time intervals before and after this exertion. The results are shown below.

Time - minutes	Lactic acid in mg/litre
0	250
3	600
10	850
12	950
20	770
30	600
40	520
50	440
60	370

Plot a graph of the results on the paper provided. Using the graph estimate how long it would take for the level of lactic acid in the blood to return to normal.

The accumulation of lactic acid in the blood is the reason we feel fatigued after strenuous physical activity. The oxygen taken in serves to remove the lactic acid from the blood. In cases of severe exertion we cannot take in oxygen fast enough and thus an 'Oxygen Debt' builds up. This explains why we pant and breathe deeply after a sprint. Although a trained athlete is far more efficient in the removal of lactic acid, there is an upper limit to the amount of lactic acid even the most highly trained athletes can tolerate. Thus we cannot expect world records to go much beyond present limits.

Wasted Energy

The energy currency A.T.P. is used to supply energy for all the functions of the body, not just the movement of muscles. It is used for growth, reproduction, running the nervous system and many other uses. When energy is used to move muscles, some of it is not used for "useful work".

Fill an ice cream container with 1000 ml of water at 10°C place one hand in the container and measure the temperature of the water every minute for five minutes. Since you must keep the hand perfectly still it is probably easier if a partner records the temperature. Remember to stir the water gently before recording the temperature.

Repeat the above experiment this time moving the fingers of the hand rapidly while it is immersed in the water. Again measure the temperature every minute for five minutes. Plot a graph of temperature against time for the two sets of results.

From the graph what do you think happens to some of the energy used to move muscles.

Assignment

Consider the process by which food is eventually converted to energy used to move a muscle. Draw a diagram below which shows the relationship between the following terms involved in the process.

OXYGEN	BLOOD	FOOD	HEAT
CARBON DIOXIDE	MUSCLE	A.T.P.	MUSCLE CONTRACTION
CELLS	LUNGS	MITOCHONDRIA	HEART

Project:

Obtain a pig's heart or a lamb's heart and disect it comparing it to a diagram of a heart in a biology text. Note the muscular walls and the valves as well as the different compartments.


HOCKEY SCHOOL
NHL rookies
NHL PLAYER PUZZLE
'French Connection'
"LEARN HOCKEY

HOCKEY IN CANADA

As you well know hockey is Canada's most popular sport. Almost every boy and a good many girls as well grow up learning to play hockey. Today millions of Canadians, young and old spend a significant portion of their time watching, listening to, or playing hockey.

The game was first played in ancient Greece in 478 B.C. It was introduced in Europe in the 12th century where it was known as the "Frozen Water Game". By 1890 it had become Canada's most popular sport. The Montreal Canadiens, formed in 1908, were Canada's first professional hockey team.

A questionnaire about your knowledge and interest in hockey appears on the following papers. Each of you should fill this out. Answer the questions as honestly as you can. After you have finished, the class data should be put on the board. Some of this data can then be grasped to show various relationships. Your teacher will give you guidance in this respect.

HOCKEY QUESTIONNAIRE

1. Sex M F
2. Age ____
3. Number of brothers and sisters in your family. ____
4. Do you own a pair of ice skates? ____
5. How many years have you been ice skating? ____
6. Do you play hockey? Yes ____ No ____
7. If you play hockey, do you:
   a) play with your friends? ____
   b) play on a school team? ____
   c) play on an amateur team?____
8. Does anyone else in your family play hockey regularly? Yes ____ No ____
9. How would you describe your interests in sports in general:
   a) very interested? ____
   b) mildly interested? ____
   c) little or no interest? ____
10. Into what classification would you place yourself:
    a) avid T.V. sports fan?
    b) occasional T.V. sports fan? ____
    c) non T.V. sports fan? ____
11. What is your favourite T.V. sport? ____
12. How many teams are there in the N.H.L.? ____
    W.H.L.? ____
13. What is your favourite hockey team? ____
14. Do you like to discuss hockey while watching it? Yes ____ No ____
15. Do you enjoy seeing rough play or fights on televised hockey games?
    Yes ____ No ____
16. Do you feel that players put on an act knowing they are on T.V?
    Yes ____ No ____
17. Do you have a favourite hockey player? Yes ____ No ____ If yes, whom? ____
18. While watching hockey games do you picture yourself on the ice?
    Yes ____ No ____
19. How many hours per week do you spend talking about or playing hockey? ____

SPORTS IN OUR LIVES

For many of us in North America, sports have an important effect on our daily lives. This is particularly true with regard to our television habits. The statement quoted below, from Super Spectator and The Electric Lilliputians by William Johnson, although specifically about football, gives you some idea of the impact of television sports on the viewer.

> The Super Spectator is upon us and it is stupefying to behold. Consider the major land mass of the North American continent on a Sunday afternoon, say January 12, 1969. From sea to shining sea on that afternoon, 60 million citizens arrange themselves before television screens. In darkened parlors . . . the country sat and the multitude was as one, oblivious to the afternoon beyond. No butterfly, no snowflake, no street fight or car wreckage at the corner would vie for attention. No this was Super Sunday for Super Spectator, the Jets versus the Colts in Miami; the 60 million were bathed as one in the moon-glow of black and white cathode tubes or the ghostly green-peach of living color. They gazed, as one, entranced by the miniature facsimile of the game on their screens. For them the Super Bowl was played by electric Lilliputians.

Some people will act in very extreme and bizarre ways if for some reason they are not able to watch their favourite game on television. During the 1972 World Series a man in Northern California became so enraged when television coverage of the last game was interrupted, that he took out his shot gun and pumped 12 pellets into his television screen.

On December 12, 1970, the father of a National Hockey League player was shot and killed after he forced his way into a television station in Prince George, because it was not carrying the Toronto Maple Leafs game in which his son was playing. Here is the Canadian Press story which appeared in a St. John's daily newspaper (The Evening Telegram, of December 14, 1970):

> Roy Edward Spencer, 59, of Fort St. James, B.C., was killed by a Mountie as he left Station CKPG. Police said he shot an RCMP Constable in the foot before he was shot himself. Spencer, the father of Brian Spencer of the Toronto Maple Leafs, had driven for two hours from Fort St. James to complain that the station was carrying an NHL game between the Vancouver Canucks and Oakland rather than between Toronto and Chicago. Official accounts of the bizarre course of events resulted from Spencer's complaints that he was being denied a chance to see his 21 year-old son play in a National Hockey League contest being shown to most of Eastern Canada. At the time of Spencer's appearance at the station, it was carrying the NHL's Vancouver-Oakland game while the rest of the country saw the Toronto-Chicago game which featured a between-periods interview with his son.

Eugene Ozon, a Newfoundland CBC sports announcer conducted a study of the effects of "Hockey Night in Canada" on white-collar workers in St. John's.

His results are most interesting. Two nights each week, HNIC, is watched by more people than any other telecast. This top rating has been maintained for over twelve years. Ozon believes that the effect of HNIC has a greater effect in Newfoundland than elsewhere because here only two television stations are available to the viewer. The Newfoundlanders studied preferred watching hockey on television to other sports on a three to one basis. A majority (57%) of these Newfoundlanders preferred to watch HNIC with friends rather than with other members in their family.

According to Ozon:

> The attraction of violence in hockey was unquestionably the most significant finding in the investigation. My data indicated a strong attraction for fights and arguments in HNIC as being an integral part of the game. To remove them from the NHL would detract from the overall enjoyment of viewing. To counteract the adverse effects this may have on children, I suggest a professional attitude toward the display of the confrontations--especially by HNIC. The desire for its continuation is evident. Seventy-two percent of the respondents said they enjoyed fights and arguments on HNIC. Approximately twenty-eight percent said they tolerated or objected to it. The desire for retention of violence as part of the game increased with the increased interest for HNIC.

SPORTS, PLAY AND WORK

Many people who have written about sports regard them as an outgrowth of play; that the play of children, through cultural refinement became what we know as sports today. Arnold Beisser, M.D. a former national tennis player, later paralyzed by polio, in his book The Madness in Sport defines play as: "To engage in a sport or diversion, to amuse oneself, to frolic or gambol. To act in a way which is not to be taken seriously." If this is so we must conclude that most Canadians occupy themselves, to a large extent with activities that are not considered too important.

By contrast Beisser defines work as: "Continued exercise or activity directed to some purpose or end; especially manual labor; hence opportunity for labor, occupation." In this sense work is productive and is the opposite of sport. Many of us have the idea that play or sport is the reward we get for work. "Get your work done so you'll have time to play." But this idea of work and play may be changing. Can arduous practice, long hours of learning signals and plays, sweating, bruising, bone-breaking practice, all in preparation for the big game, really be called anything but work?

There is an interesting illustration of the complete reversal of the relationship of work and play. Those sports which began as play, such as hockey and football, have now lost that playful and lighthearted characteristic, and have taken on all the qualities of hard, serious work. Hunting and fishing, in contrast, began as the soul of work, and remain so to some extent in Newfoundland. But in most of Canada, hunting and fishing have assumed the true spirit of play; they are carefree, amateur, diversional recreation.

PHYSICAL FITNESS AND SPORTS - A DEBATE

One of the main justifications given for sports (hockey) programs in high school and college is that such activity contributes to better physical fitness. This of course, does not apply to those who only watch the game either at the stadium or on television. It is true that to play good hockey requires stamina and good physical conditioning. But if you look at the number and extent of injuries sustained by both amateur and professional players, you may wonder if regular hockey playing contributes to overall good health.

This would be an interesting and important topic for class discussion and debate. Your teacher will help you in getting started.

SPORTSMANSHIP

> "When the one great scorer comes to write against your name -
> He marks - not that you won or lost - But how you played the game."
>
> ... Grantland Rice: Alumnus Football

Being a good sport, or showing sportsmanship is a major, if not the major, goal of playing sports. At least that is what we are taught by our parents, coaches and teachers. Webster defines a sportsman as:

> A person who can take loss or defeat without complaint, or victory without boasting and gloating, and who treats his opponent with fairness, generosity, courtesy, etc.

These are strong ideals. But how well do we live by them? Men probably first came together in groups because this arrangement could provide protection from natural enemies and could aid in providing food and shelter. But as men and women began working together other problems such as competition, rivalry, jealousy and violence within the group developed. It is likely that sports were invented and developed as a means of providing an alternative release for anti-social behavior. If sports can confine aggression and violence to the athletic field then so much the better. This release or "letting off steam" is not restricted to the athlete alone but is something that the spectator can share in as well.

To some people however it seems a bit odd, and in fact dishonest, to see athletes battling against each other at one moment, and embracing and congratulating each other the next moment. Sportsmanship is an ideal goal, but one which in practice may be difficult to achieve.

THE PROBLEM OF WINNING - ANALYSIS OF AN ARTICLE

The stated objective in all sports contests is to win. The rewards (praise, money, prizes, trophies, etc.) go to the winner. What if anything is left to the loser? At most he has a chance to try again. It is clear that given the structure of sport contests that there are going to be very many more losers than winners. Is this healthy? Some argue that the game of winning and losing is one we must play in daily life so the practice we get through sports will aid us in our practical work. You are familiar with this argument.

One of the major objectives of this and other modules is to give you practice in critically analyzing various points of view, especially those that are presented by so-called experts. There is no question that this will be of value to you when you leave school. On the following pages we have reproduced an article by George Leonard, "Winning isn't Everything. It's Nothing", from the Esalen Sports Symposium. It presents another and infrequently dealt with point of view. Read it carefully at home and be prepared to discuss its pro's and con's in class.

By George B. Leonard
From the Esalen Sports Symposium

Underneath our obsession with victory lies fear. Even after you win your own particular Super Bowl, what about next year?

Sports and Competition

WINNING ISN'T EVERYTHING. IT'S NOTHING.

In less than a generation, the prevailing sports ethos in America has shifted from, "It's not whether you win or lose, it's how you play the game," to "Winning isn't everything. It's the only thing." The current public glorification of winning at all costs came to the fore during a war we did not win. Sermons by top corporate executives on hot competition as the American way were being directed at the younger generation during a period when many of these same executives were making every effort to get around the federal regulations against price-fixing and illegal cooperation among corporate "competitors." The use of sports terminology by our national administration became commonplace just before the nation learned how misleading and disastrous "game plans" and "enemy lists" can be.

If winning has become our national religion, the Super Bowl is its apotheosis. But the ceremony, in spite of the huge crowd, the music, the flags, the pompom girls, the special coin struck off in memory of the late Vince Lombardi, is somehow unconvincing. We are embarrassed when the three Apollo 17 astronauts, paraded out to lead the Pledge of Allegiance, become confused, make several false starts and look at each other to see if the right hand should be placed over the heart. And we are perhaps relieved when their ordeal ends and a disembodied voice floats out over the stadium: "Now, to honor America, let's join The Little Angels for the singing of the national anthem."

Contradictions, anomalies and grotesqueries in the current sports scene should not surprise us. A neurosis asserts itself most painfully and insistently just as it is being uprooted and cast out. The final period in any evolutionary line of development—of a biological species, an artistic movement or a society—is often marked by convolution, overspecialization and other bizarre extremes. If, as many scholars have pointed out, a society's sports and games mirror its basic structure, then what we may be seeing in the current worship of hot competition and winning at all costs is the end of a particular line of social development. The Super Bowl may ultimately stand as a symbol of a culture in transformation.

Because our own sports are so highly competitive, we may tend to believe that all human beings, especially males, are born competitors, driven by their genetic nature to the proposition that winning is "the only thing." The games of many cultures, however, have no competitive element whatever. For example, the Tangu people of New Guinea play a popular game known as *taketak*, which involves throwing a spinning top into massed lots of stakes driven into the ground. There are two teams. Players of each team try to touch as many stakes with their tops as possible. In the end, however, the participants play not to win but to draw. The game must go on until an exact draw is reached. This requires great skill, since players sometimes must throw their tops into the massed stakes without touching a single one. *Taketak* expresses a prime value in Tangu culture, that is, the concept of moral equivalency, which is reflected in the precise sharing of foodstuffs among the people.

"The notion that humans evolved through relentless competition with nature and each other is false"

Indeed, the notion that humans evolved only through relentless, grinding competition with nature and each other is a false one. The familiar cartoon showing the caveman as a brutish creature carrying a club with one hand and dragging a woman by the other tells us nothing about primitive life. The Stone Age peoples that survive in remote corners of the world are, until we meddle with them, usually gentle and sensitive, with a fine ecological sense. The recently discovered Tasaday tribe of Mindanao in the Philippines, true Stone Age cave dwellers, have no words for "hate" or "fight." They are cooperative and loving. The brute in the cartoon is our secret image of ourselves.

Darwin's theory—natural selection, the "survival of the fittest"—is sometimes cited as justification for hot competition. Social philosophers of the propertied, industrial classes in the late nineteenth and early twentieth centuries promoted a brutal, jungle philosophy, but it was based on Darwin's account of the predatory rather than the social animals. This social Darwinism was long ago discredited. Charles Darwin is clear on the point that, for the human race, the highest survival value lies in intelligence, a moral sense and social cooperation, not competition.

Among the English-speaking peoples, the close and inevitable relationship between sport and competition is of fairly recent origin. According to *Webster's New International Dictionary* (second edition), the word "sport" comes from "disport," which originally meant "to carry away from work." The first definition applied to the word is, "that which diverts and makes mirth; pastime; amusement." In a series of definitions 40 lines long, there is no mention whatever of competition and only one brief reference to sport as a "contest."

The attempt to justify hot competition as an essential aspect of human existence goes on in the face of all the evidence. There exists, for example, a common assumption that competition is needed to "motivate behavior." Yet no study has shown that competition necessarily motivates behavior any more effectively than other means—extrinsic reinforcement, for instance, or even the sheer joy of doing something well. To see the real function of competition in our society, we must look deeper.

In 1967, I collaborated with Marshall McLuhan on an article entitled, "The Future of Education." Our idea sessions ranged over a number of topics but kept coming back to the question of competition and why it is so tirelessly proclaimed, not only by coaches, but by educators and all those traditionalists who concern themselves with shaping the lives of our young people. At last, McLuhan came forth with one of his "probes"—a sudden thought from an unexpected direction.

"I know," he said. "Competition creates resemblance."

To compete with someone, in other words, you must agree to run on the same track, to do what he is doing, to follow the same set of rules. The only way you'll differentiate yourself is by doing precisely the same thing, slightly faster or better. Thus, though performance may improve, the chances are you will become increasingly like the person with whom you compete.

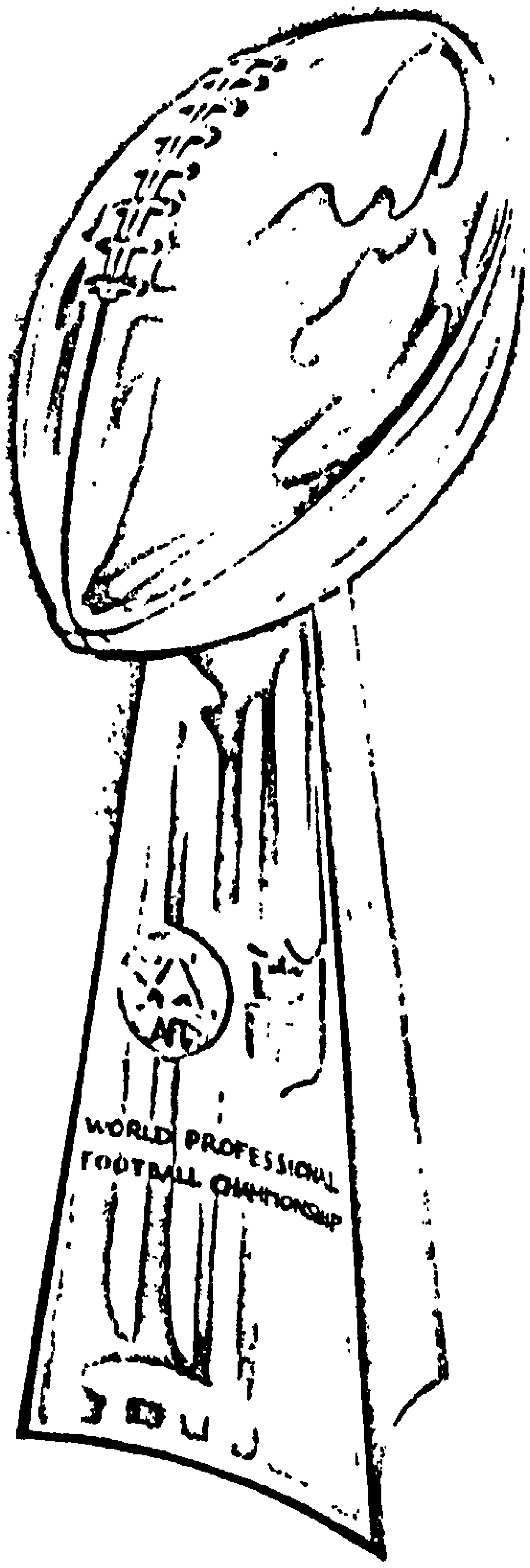
In this light, it is easy to see that a culture dedicated to creating standardized, specialized, predictable human components could find no better way of grinding them out than by making every possible aspect of life a matter of competition. "Winning out" in this respect does not make rugged individualists. It shapes conformist robots. Keep your eyes open during the football season. The defensive ends begin to look more and more alike. The cornerbacks become ever more interchangeable.

The final argument for hot competition all the way down to nursery school is that competition makes winners. The argument is, at best, half true. It makes nonwinners, too—generally more nonwinners than winners. And a number of studies indicate that losing can become a lifelong habit. What is more, when competition reaches the present level, the argument becomes altogether false. As proclaimed by the more extreme coaches and sportswriters today, competition makes us—all of us—losers.

Between 1958 and 1971, the San Francisco Giants had the best overall won-lost record in the National League. For five straight years, from 1965 through 1969, they finished in second place. To do so, you would think, they must have "won out" over many other teams. Increasingly during this period of second-place finishes, however, they came to be characterized by fan and sportswriter alike as born losers.

"Winning isn't everything. It's the only thing." And in our present-day sports culture, that means being Number One, Numero Uno, the one and only.

Take the Dallas Cowboys. For five straight years, from 1966 through 1970,



the Cowboys won their division championships, then were eliminated, either in the play-offs or finally, in January of 1971, in the Super Bowl itself. And what was said of this fine professional football

"Competition makes more nonwinners than winners. Studies indicate that losing can become a habit."

team during this period of unprecedented winning? They "couldn't win the big ones." They were, you see, just losers.

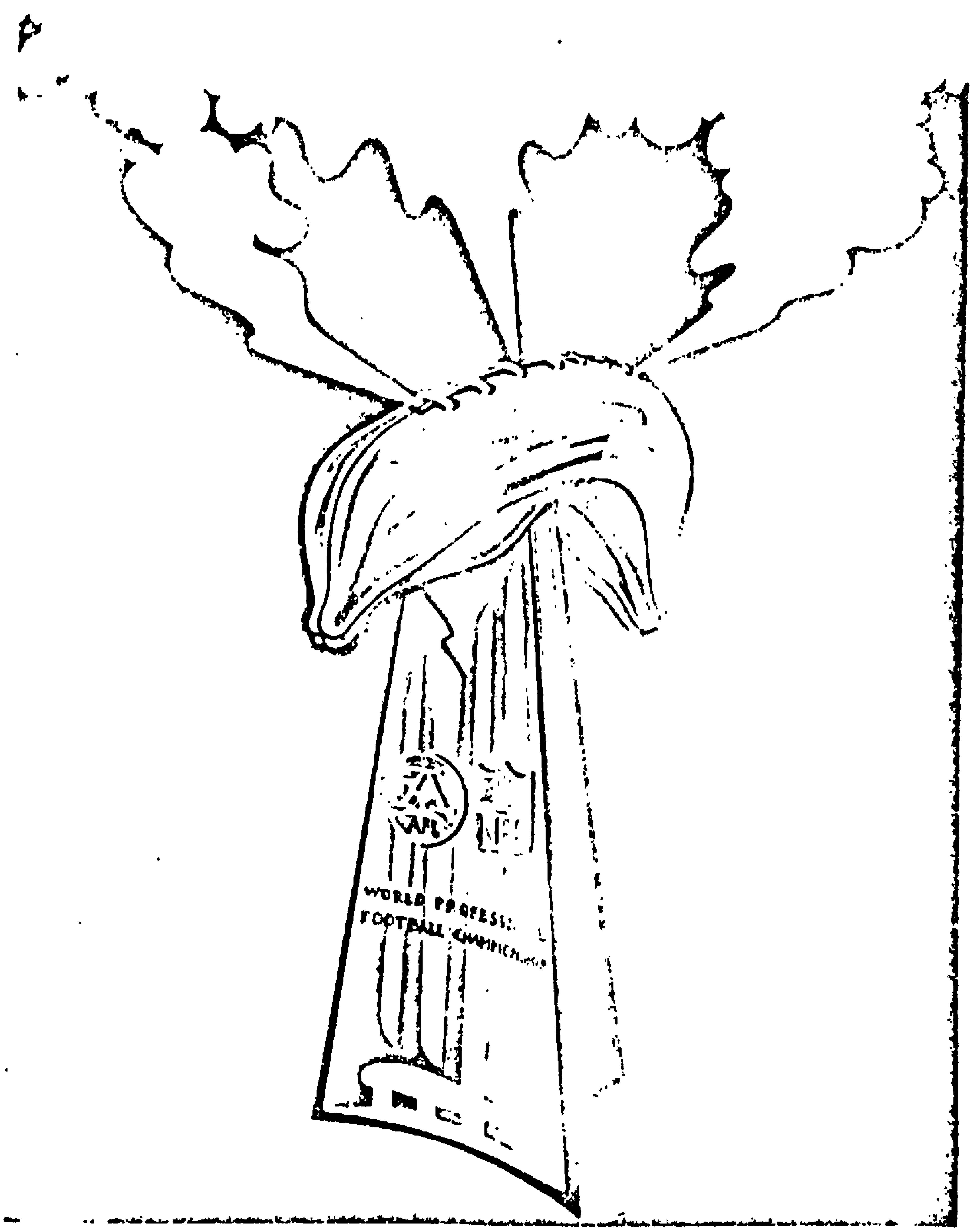
When the Cowboys did at last win the Super Bowl, in January 1972, it became apparent that the players themselves had been swept up in the Numero Uno mystique. One by one they came to the TV cameras after the game to affirm that nothing had really meant anything except this victory. The champagne flowed. The players were probably happy for a moment, but their faces were not entirely unclouded. And the mask of fear that coach Tom Landry wears along the sidelines during every game when his winning record is threatened was not entirely erased. The problem is this: even after you've just won the Super Bowl—*especially* after you've just won the Super Bowl—*there's always next year.*

If "Winning isn't everything. It's the only thing," then "the only thing" is nothing—emptiness, the nightmare of life without ultimate meaning. This emptiness pursues us wherever "winning out" is proclaimed as God. I once spoke to a group of top-ranking industrialists in a seminar session and argued that hot competition is far from inevitable in the future. As my argument developed, I noticed a look of real anxiety on some of the faces around me. One industrialist finally spoke up, "If there is to be no competition, then what will life be all about?" We would probably be appalled to discover how many people in this culture have no notion of accomplishment for its own sake and define their own existence solely in terms of how many other people they can beat out.

Only through this viewpoint can we understand how a talented young athlete can let himself become what Gary Shaw in his new book has called *Meat on the Hoof*, a commodity to be manipulated, hazed, drugged, used, traded and discarded. And we may be able, by imagining the emptiness that accompanies "winning," to comprehend why (as David Meggyesy has revealed in his book, *Out of Their League*) a prototype of supermasculinity would allow himself to be treated in the manner of a eunuch, prevented at times from having sexual relations with his own wife.

There is nothing wrong with competition in the proper proportion. Like a little salt, it adds zest to the game and to life itself. But when the seasoning is mistaken for the substance, only sickness can follow. Similarly, when winning becomes "the only thing," it can lead only to eventual emptiness and anomie.

The time has come, I feel, to blow the whistle on this madness. We may not be able to turn the American sports juggernaut around overnight, but we can suggest that sports are possible without beating the brains out of the opposing team, and that it may be possible for players and fans alike to take great pleasure in a beautiful play, even if it's executed by the opposition. We can start working out new sports that are noncompetitive or less competitive or in which competition is placed in the proper perspective, as a matter of good sport and good humor. We can start looking for the larger potentialities that actually already exist in the realm of sports and games.



Our present way of life, based upon endless, ever-increasing expansion of the production and consumption of energy, is eventually doomed. And so much else is based upon that expansion—our definition of job and full employment, our inculcation and suppression of aggression, our attempts to fix consciousness at a single point, our whole neurosis structure, our glorification of what we call "competition" and "winning." The present rate of expansion in the United States can go on for a few more decades, but then it comes up against the most fundamental law of thermodynamics. Even with perfectly clean nuclear energy, the final result of all our burning and wasteful consumption will be the overheating of this small planet. We must seek alternate modes of life, other ways of being on this earth.

"There is nothing wrong with competition in the proper proportion. Like a little salt, it adds zest to life."

Changes are coming. Sports represent a key joint in any society. To turn this society toward peaceful, humane change, we can begin with reform of sports. Some intellectuals have ignored this aspect of our life, believing somehow that sports are beyond serious consideration. They are quite mistaken. There is nothing trivial about the flight of a ball, for it traces for us the course of the planet. Through the movement of the human body, we can come to know what the philosopher Pythagoras called *kosmos*, a word containing the idea of both perfect order and intense beauty. Sports are too beautiful and profound for simplistic slogans. How we play the game may turn out to be more important than we imagine, for it signifies nothing less than our way of being in the world.

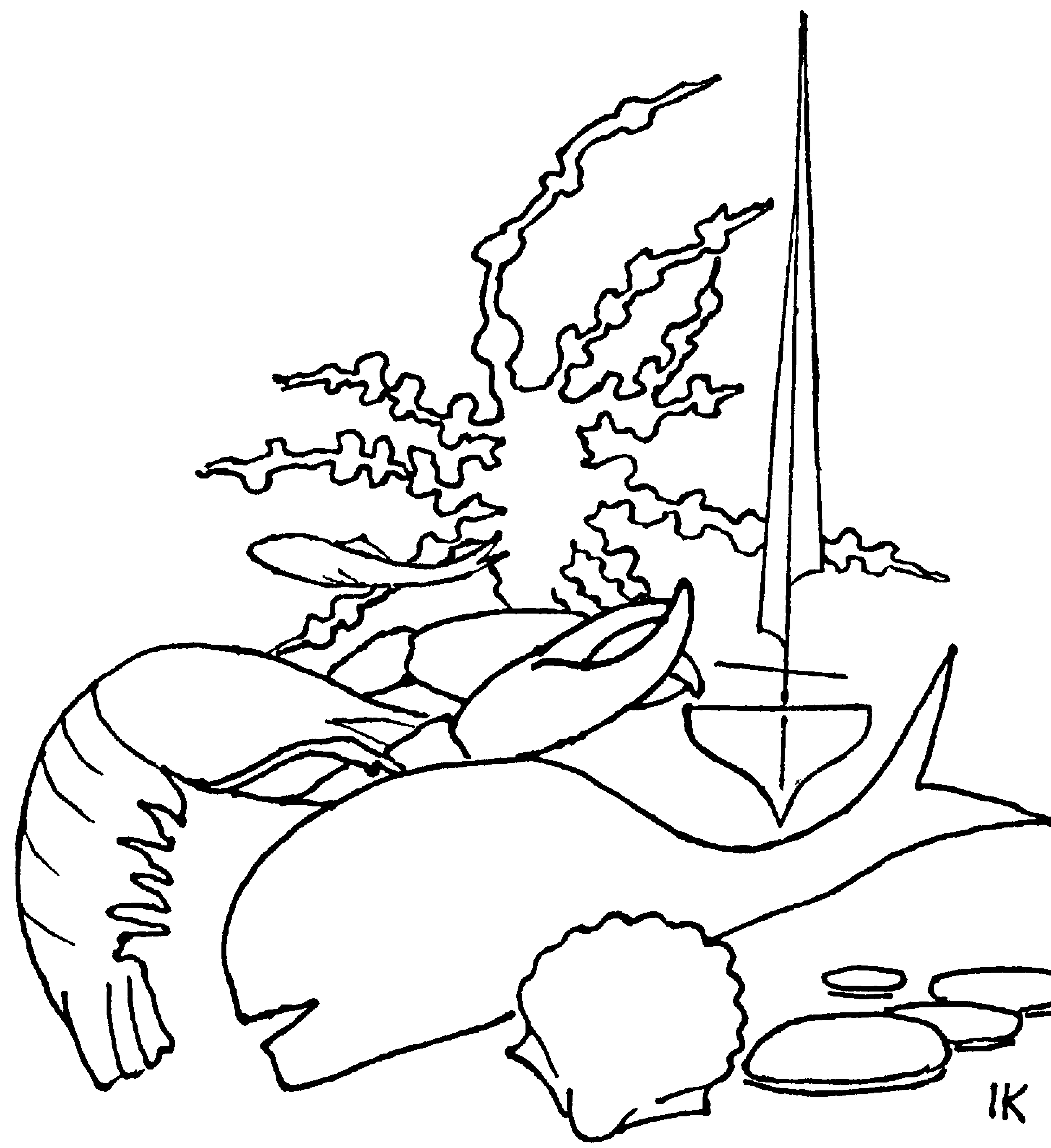
INTEGRATED SCIENCE FOR NEWFOUNDLAND

MODULE IV — THE SEA

SCHOOL: ______________________________

NAME: ______________________________

THE SEA



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I. INTRODUCTION

The history and development of Newfoundland has been closely linked with the sea. For many Newfoundlanders the sea is still their livelihood and many communities are still dependent on the sea for their link to the outside world. In this module we are going to consider some aspects of the science of the sea. What the sea is composed of, the life we find in the sea, why things float, adaptation to life in the sea and many other topics developed from the theme the sea.

Before you start on the science of the sea try the following quiz, and see how much you know about the sea. Your teacher has the answers.

1. How much of the Earth's surface is covered by the sea?

2. Which is the largest ocean in the world?

3. Where is the deepest part of the ocean?

4. What is the height of the largest sea wave recorded?

5. Where are the largest tides recorded?

6. Which is the longest seaweed?

7. Which is the largest species of fish?

8. Which is the fastest fish?

9. Which is the saltiest sea?

10. Which species of whale is the largest?

How many did you score? Some of these questions you will deal with in this module. Answering the above questions may have prompted you to think of some others. Write in the space below any other questions you can think of about the sea. At the end of the module see how many of your questions you can answer.

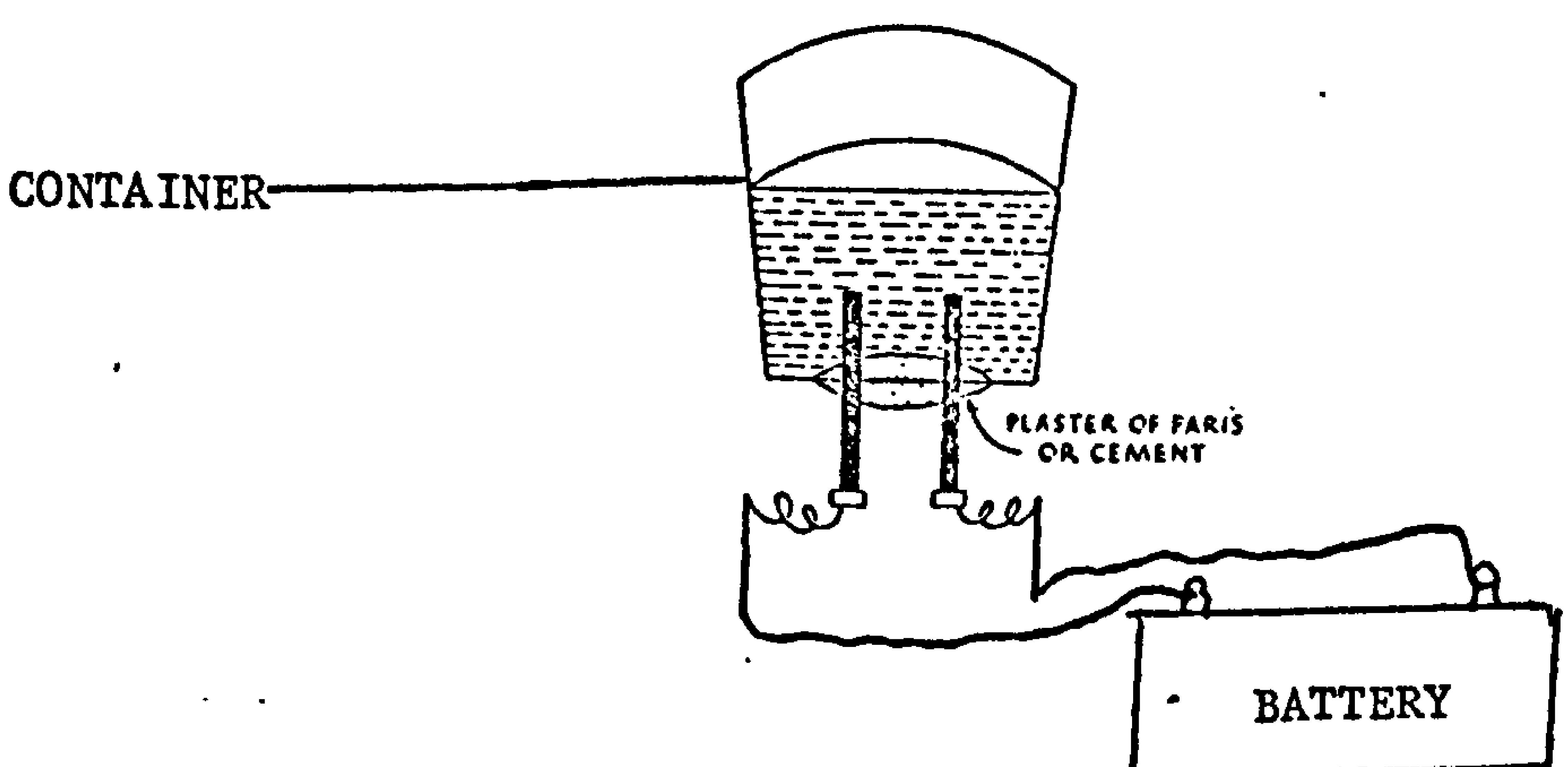
II. WATER, WATER ALL AROUND US -------

This first unit deals with some of the properties of seawater, but before we investigate seawater let us find out something about water itself. Water is one of the commonest substances on the earth, after all the oceans themselves are composed of roughly 97% water. Although water is in abundance in our environment it is an unusual substance, and it is because of the abnormal nature of water that life can exist on our planet.

Water - A compound

Water is a PURE SUBSTANCE, by that we mean that every part of a sample of it is the same. If we were able to magnify a sample of water, even to the extent that we could see atoms (incidently we cannot do this, no one has ever seen an atom, they are just too small!) each part of the sample would be the same.

Although water is a pure substance it can be split into two substances, the easiest way to do this is by passing electricity through it. The apparatus shown below enables you to split water up by passing electricity through it. The process is called the ELECTROLYSIS of water.



Pure water itself will not allow electricity to pass through it, and so we must add something to enable it to conduct electricity. Your teacher will give you some water to which has been added a little washing soda. When you have your apparatus set up, connect the carbon rods to the battery as shown. Collect the gases given off at the carbon rods by filling two test tubes with water, turning the tubes upside down, (you will need to keep your thumbs over the ends of the tubes until the ends are under the surface of the water) and placing them over the carbon rods. NOTE: WASH YOUR HANDS IMMEDIATELY AFTER YOU HAVE DONE THIS, TO REMOVE ANY WASHING SODA.

Record your observations below.

When the text tubes are filled remove the one which filled first, carefully trapping the gas inside with your thumb over the end of the tube. Bring a lighted splint of wood to the mouth of the tube. What happens?

This gas is HYDROGEN one of the basic substances from which water is composed.

Repeat the procedure with the second tube, only this time blow the splint out just before you push it into the tube, it should still be glowing as it goes in. What happens?

This gas is OXYGEN the other basic substance from which water is composed.

Sometimes water is called H_2O, on the basis of what you observed can you explain this?

You have seen that water, a pure substance, can be split up into other substances hydrogen and oxygen. Scientists have been unable to split up either hydrogen or oxygen into other substances, and so these appear to be basic substances or ELEMENTS. There are approximately a hundred elements known to man of which Hydrogen and Oxygen are two. Elements are simple substances from which nothing simpler can be made.

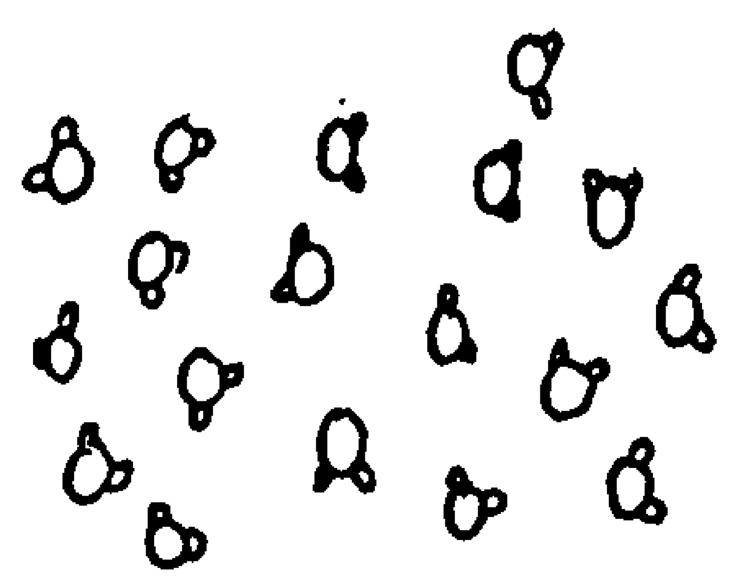
Water belongs to the group of substances called COMPOUNDS, they are pure substances which can be split up into two or more ELEMENTS.

Consult a chemistry textbook for a table of elements, how many have you heard of? Although 92 elements occur naturally (the rest are artificial, they have been made by scientists in laboratories) we generally only come across a few of them in our everyday lives.

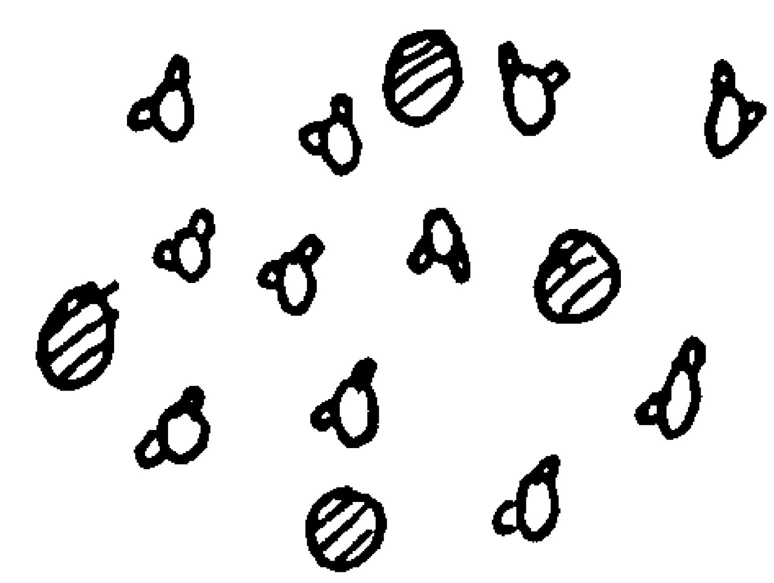
Seawater - A Solution

In the first part of this section we found out a little about the composition of water. You may remember that water is a pure substance, a compound composed of hydrogen and oxygen combined together. Seawater however, is a MIXTURE, not all parts of a sample are the same. Now if we look at a beaker of seawater it certainly appears to be pure, but if we were able to magnify it until we could see individual atoms we would see that not all parts of the sample are the same. However we cannot in fact do this. Why?

Below is a diagram which represents what we think water and seawater would look like if we were able to see the individual particles.



Water, all particles the same. Each molecule of water composed of one oxygen atom and two hydrogen atoms.



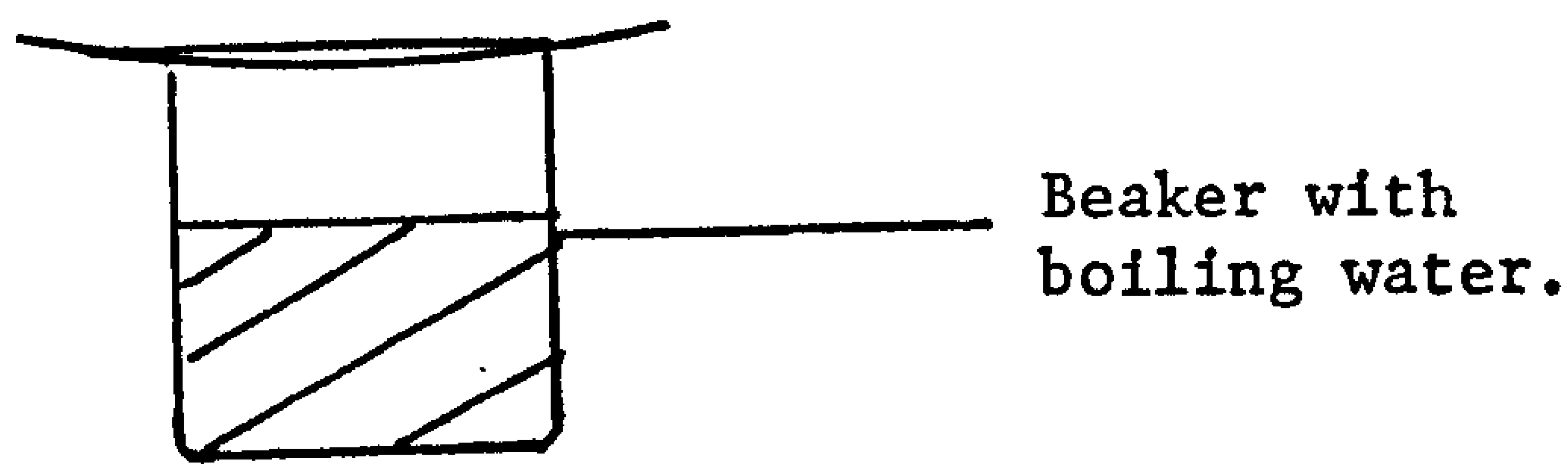
Seawater, a mixture

Seawater is a mixture of water together with many minerals. Often we think of seawater as simply "salty water", however seawater contains many other substances besides sodium chloride. The table below gives the more common salts present in a sample of seawater.

Name of Salt	Chemical Formula	Grams of Salt per 1000 Grams of Water
Sodium Chloride	$NaCl$	23.0
Magnesium Chloride	$MgCl_2$	5.0
Sodium Sulphate	Na_2SO_4	4.0
Calcium Chloride	$CaCl_2$	1.0
Potassium Chloride	KCl	0.7
Others		0.8
TOTAL		34.5

We can separate the salts from seawater fairly easily, although it is considerably more difficult to separate the individual salts from one another.

Evaporate a sample of seawater slowly over a water bath. A watch glass or other shallow dish, such as an aluminium pie dish, is ideal.



As you evaporate the sample, remove small amounts from time to time and allow them to cool on a microscope slide. Observe with a hand lens or microscope, and sketch the shapes of any crystals that you see.

Water is often called the 'Universal Solvent', this simply means that most materials will dissolve in it. Thus even glass is slightly soluble, and if you drink a glass of Coke or other soft drink you are in fact drinking a small amount of glass as well. The amount of a given material that will dissolve in a given amount of water varies considerably. Some materials dissolve very easily, while others dissolve very sparingly, oil for example dissolves very poorly in water. What consequence does this have for oil pollution?

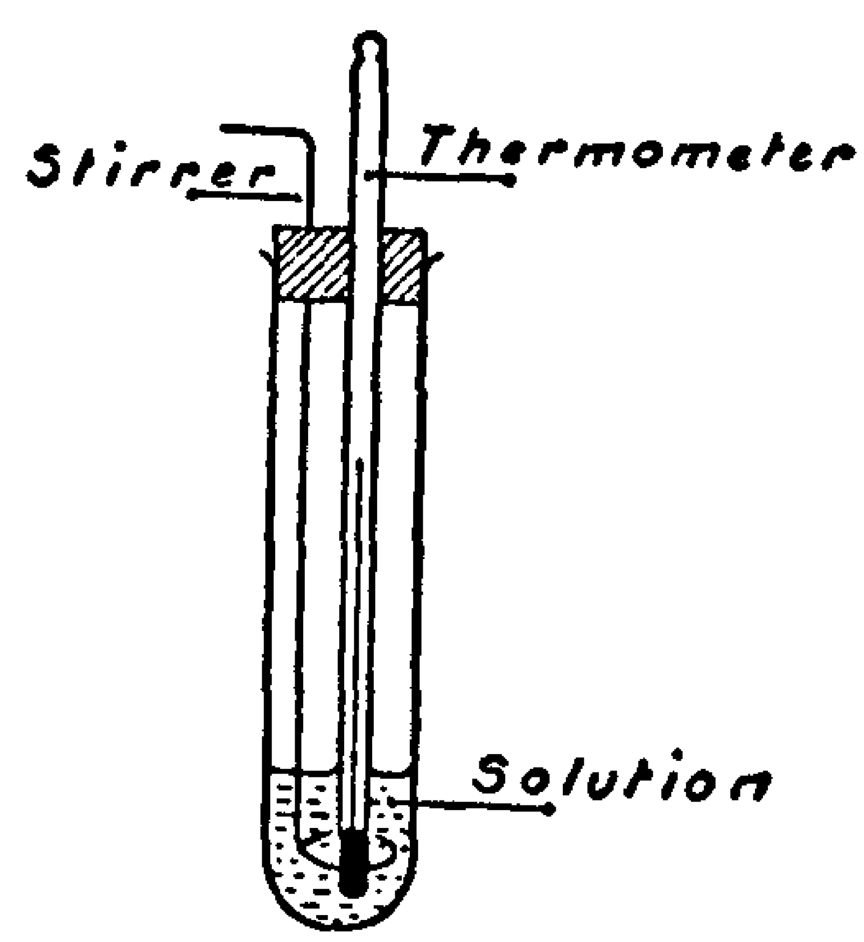
Add a little sodium chloride to a sample of seawater in a test tube and shake for a minute or so. Does any of the sodium chloride dissolve?

When a liquid, THE SOLVENT, can dissolve no more of a substance, THE SOLUTE, the solution is said to be saturated with that substance. Is seawater saturated with sodium chloride?

The amount of a given solute that will dissolve in a solvent depends on the temperature of the solvent. In this next exercise the class is going to investigate how temperature affects the solubility of a solute. When we compare solubilities we generally quote them as the amount of solid that will dissolve in 100 grams of water. Thus the solubility of common salt is 36 grams in 100 grams of water. This means that a SATURATED SOLUTION of salt contains 36 grams in 100 grams of water. No more sodium chloride would dissolve in such a solution.

Instead of using sodium chloride in this exercise you are going to use Potassium Chlorate. Potassium Chlorate is more convenient to use for this experiment.

Weigh out the amount of Potassium Chlorate that your teacher tells you. Add 10 ml (10 grams) of water to it in the text tube and warm gently. Stir until all the Potassium Chlorate has dissolved.



Remove the test tube from the heat and continue to stir, allow the solution to cool. Stir continually and observe the temperature when the first crystals form. Record the temperature.

Because crystals of Potassium Chlorate formed, it meant that the solution could dissolve no more potassium chlorate at that temperature. What sort of solution is this?

Your solution contained __________ grams in 10 grams of water. How much would dissolve in 100 grams of water?

The solubility of Potassium Chlorate at ________°C = gram/100 gram of water.

Record your result on the blackboard. When the class has finished write the results in a table in your book.

Plot a graph on the paper provided to show how the solubility of Potassium Chlorate Changes with temperature. From the experience of your everyday life do most solids show the same behaviour as Potassium Chlorate?

Do Gases show the same sort of behaviour?

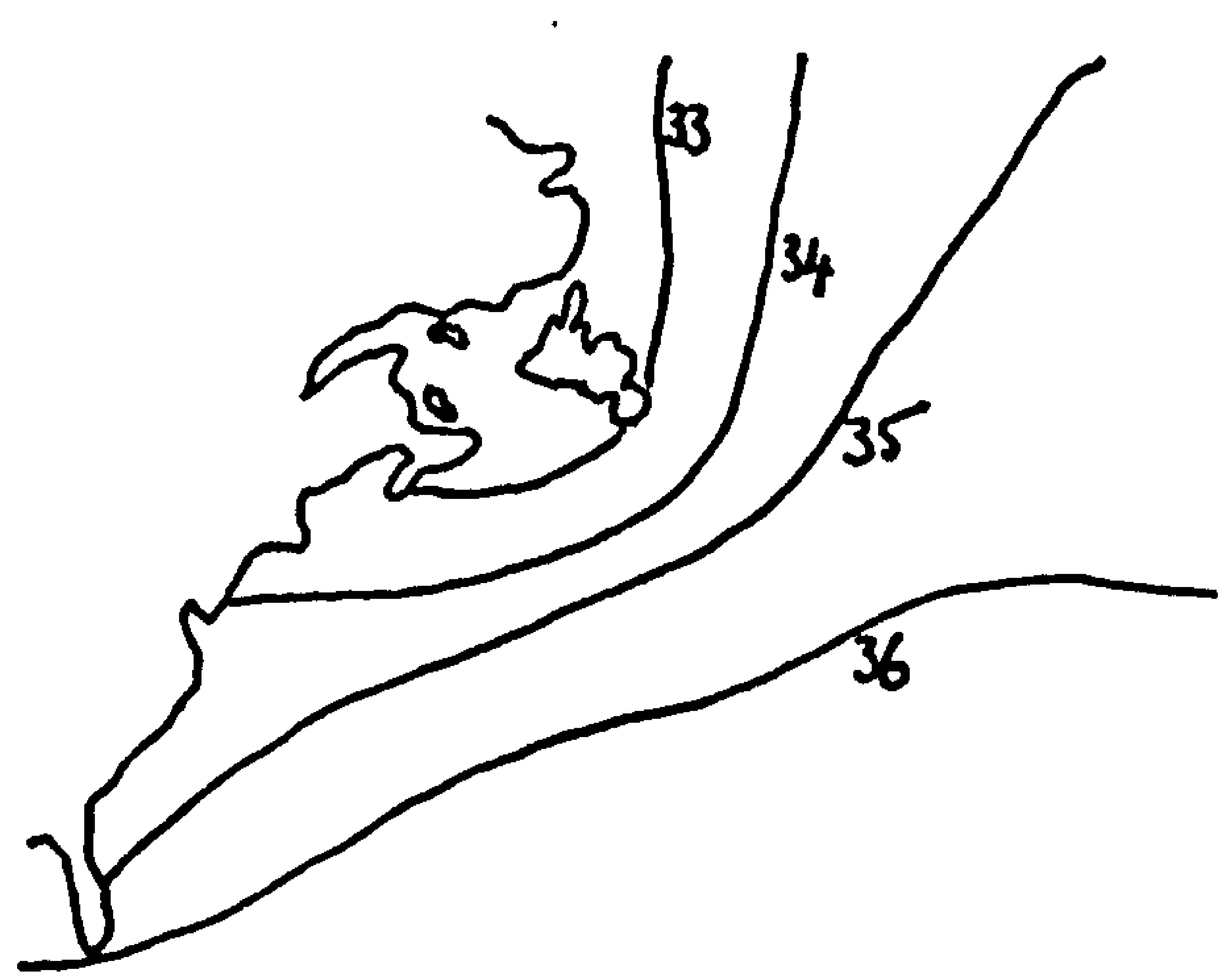
The water in the sea is far from being saturated with minerals. You have already found that you can dissolve sodium chloride in seawater. Figures for salinity are usually given in parts of salts per thousand parts of water. The average salinity of ocean water is about 35. This means that there are 35 grams of salts in 1000 grams of water. Only one figure is quoted, the total amount of salts present, since it is found that the individual salts are present in a fixed ratio.

An interesting question is how did all the minerals get into the sea in the first place? The obvious explanation is that they are produced by weathering of the Earth's crust. The minerals are then washed down by rains and carried into the oceans by rivers. However scientists have calculated that this process would only cause an increase in the salinity of the oceans of 1% in 6 million years. This certainly is not enough to explain the present mineral concentration of the oceans. Some of the minerals also come from the ocean floors. Another possibility is that some of the substances present in the sea were once present in our atmosphere. Gases such as chlorine and hydrogen chloride may have been present in the Earth's atmosphere as the Earth formed. These were then removed from the atmosphere by rain which washed them into the sea.

Most organisms have body cells which have a lower salt content than the sea. Scientists, believing that life evolved in the oceans argue that this supports the idea that the seas were once less salty than they are now. Note this is an inference, it cannot be regarded as proof that the oceans were once less salty than they are now.

The salt content of the oceans varies throughout the world. The amount of salt present depends on the temperature and the amount of precipitation. When the air temperature is high evaporation of water from the surface of the ocean occurs which will increase the salt content.

The diagram below shows the salt concentration of the surface water of the Atlantic around Newfoundland. The lines are called ISOHALINES they are lines of equal salt concentration.



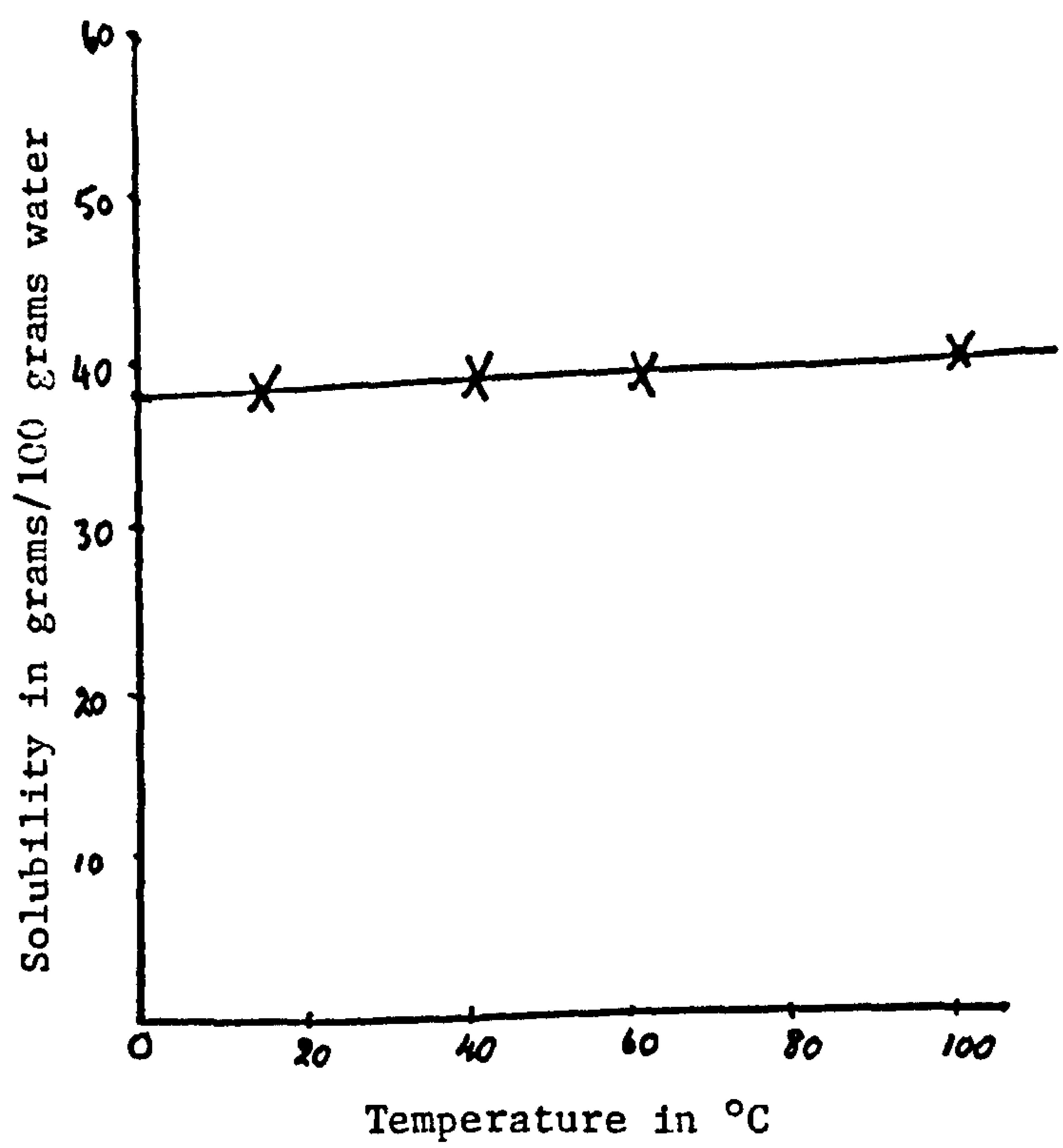
Answer the following.

a. Does the salt content of the atlantic increase or decrease as you travel South towards the equator? Explain why.

b. The following bodies of water such as the Dead Sea, the Red Sea, the Mediterranean Sea and the Great Salt Lake have high salt concentrations. Explain why this is. It may help to locate these places on a map first.

Assignment:-

The graph below is a solubility graph for SODIUM CHLORIDE, common salt. The following questions are based on this graph, and the graph you drew from your class results.



a. How does the solubility of Sodium Chloride change with temperature compared to the solubility of Potassium Chlorate?

b. At 20°C which is the more soluble, Sodium Chloride or Potassium Chlorate?

c. At 90°C which is the more soluble, Sodium Chloride or Potassium Chlorate?

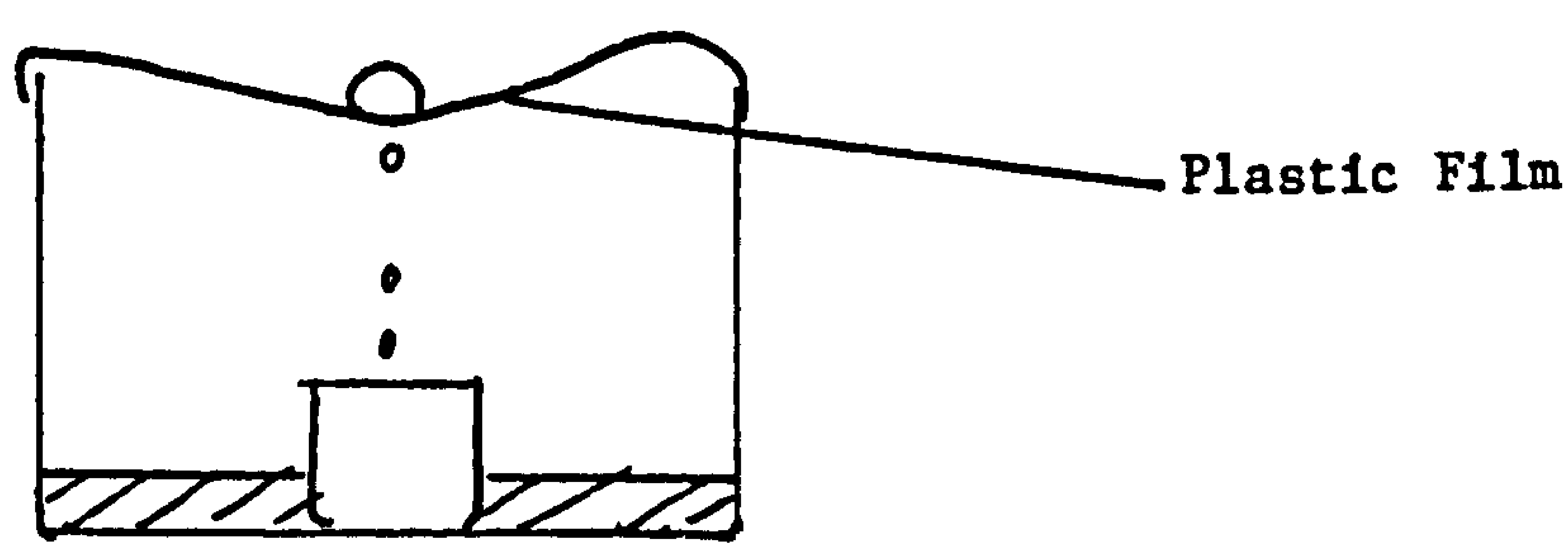
d. At what temperature are the solubilities of Sodium Chloride and Potassium Chlorate the same?

e. If a sample of seawater at 20°C contains 2.3 grams of sodium chloride in a 100 grams of water how much more sodium chloride can dissolve in it before it is saturated?

<u>Project</u>:-

1. Many countries suffer from a shortage of water and yet border or vast amounts of it in the oceans. A great deal of attention is being given to methods of obtaining fresh water from seawater. Although it is not difficult to separate pure water from seawater it is not a cheap process, and many countries cannot afford the expense. You can manufacture a distillation apparatus very easily, in fact it is often used as a way of obtaining water in an emergency.

Take a large shallow container and pour seawater into it to about a depth of one inch. Place a small container in the centre of the pan, a beaker will do. Cover the container with plastic film, taping it to the edge of the container with scotch tape. Place a small weight on top of the plastic film so it makes a depression directly over the beaker. Put your still in the sunlight or under a strong lamp, 150 watt or at least 100 watt. Water will evaporate from the seawater, condense on the film and collect in the beaker. See how much you can collect in an hour.



You could try the same method in order to obtain water from the soil. Dig a hole in damp soil about 18" deep, place a beaker in the centre of the hole. Cover the hole with plastic film, you will have to use rocks at the edges to hold it down. Place a weight on the film above the beaker as before and sit back and wait. This method depends on the Sun's energy, it is a solar still. You will need a sunny day in order to do it!

2. Use the apparatus you used for the electrolysis of water to electrolyse seawater. Describe what you observe. Can you recognise the smell of the gases produced? Try the same experiment with a concentrated salt solution. Place a piece of pink litmus paper in the solution, and observe what happens. Consult a chemistry text to explain what happens.

Water - A Reservoir of Heat

A large body of water such as an ocean has a considerable effect on the environment. However before looking at the large scale effect of water let us find out about its behaviour on heating and cooling on a smaller scale.

In this exercise you will draw a cooling curve for a sample of seawater, and compare it to the cooling behaviour of another liquid. Pour 200 grams of seawater into a beaker and heat it to a temperature of about 80°C.

Remove the beaker from the heat source and stand it on an asbestos mat. Take the temperature of the water every 1 minute as it cools, until the temperature reaches 50 C. Before you take a temperature reading stir the seawater. Record your results in a table, and plot them on the graph paper provided.

Examine your graph carefully and answer the following questions.

1. Does the water cool at a constant rate? Explain your answer.

2. How long did it take to cool from 70°C to 65°C?

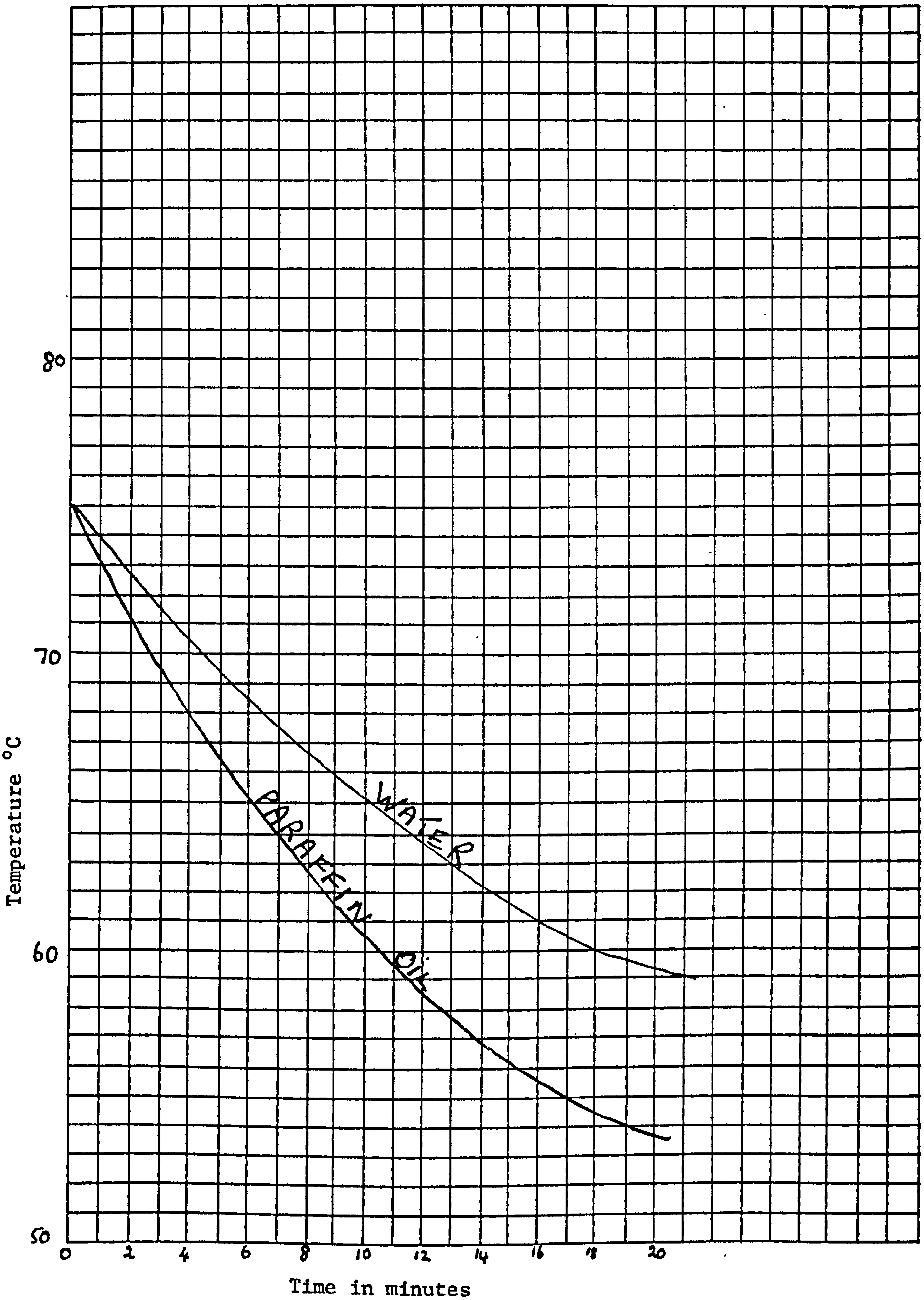
   Express this as the number of degrees cooled per minute. This is the rate of cooling.

3. What is the rate of cooling during the time the water cooled from 60-55°C?

4. Estimate from your graph the approximate time it would take to cool the water to room temperature.

In order to compare the behaviour of seawater with other liquids, you should repeat the experiment using another liquid; however, because of the length of time involved in the experiment this has been done for you. The second graph shows two cooling curves one for water and the other for paraffin oil. The data for the graphs was collected using 200 grams of each substance allowed to cool under identical conditions. Why is this important?

Examine the two graphs, and compare the rates of cooling for the two liquids. Which liquid takes the longest to cool down? Justify your answer using data from the graph. Remember that for a fair comparison you must compare the two liquids over the same temperature range.


80
70
60
50
Temperature °C
0
2
4
6
8
10
12
14
16
18
20
Time in minutes
WATER
PARAFFIN OIL

You have seen that water cools down more slowly than paraffin oil if they are compared under the same conditions. It appears that water has a greater capacity to store heat than paraffin; it has a high HEAT CAPACITY. In fact water has a higher heat capacity than nearly any other liquid. Similarly if you had carried out the experiment you designed for an assignment, you would have seen that water warms up slower than paraffin oil, or nearly any other liquid that you compared it with.

In order to compare the behaviour of substances to soak up heat or to lose heat scientists use a measure called SPECIFIC HEAT. The specific heat of water is 1.0 and very few substances have a value as high as this. Thus iron has a value of 0.1, which indicates it will absorb 1/10 of the heat that water will, or stated another way ten times more heat is stored in water than in an equal mass of iron at the same temperature.

A large body of water such as an ocean represents a considerable store of heat which has a marked effect on climate. Imagine you were to take a trip from Mid-Pacific to Mid-Atlantic on the 50°N latitude in January, (a map of the world will help you follow the journey). Over the Mid-Pacific the average monthly temperature is 6°C, as you approach Vancouver the average temperature is 2°C, over the centre of the continent around Winnipeg it is -14°C. Arriving at Newfoundland you would find the average temperature -6°C, over the Mid-Atlantic the average temperature is 6°C.

If you made the trip in July you would observe the following temperatures, Mid-Pacific 14°C, Vancouver 17°C, Winnipeg 20°C, St. John's 14°C, while in Mid-Atlantic it is 12°C.

Explain the temperature variations that occur in the course of the two journeys.

Project:- You will need a sunny day for this.

Investigate the effect of the Sun's radiation on the temperature of soil and water by the following experiment. Obtain three shallow dishes, aluminum pie plates serve very well; in one place dry soil, in the second water and in the third a mixture of soil and water. Allow them to stand in a shaded area until they all read the same temperature; check with a thermometer. Then expose them in the sunlight, but sheltered from the wind, and measure the temperature every 5 minutes for 40 minutes. Record your results and explain your observations.

Assignment:-

So far you have been concerned with a substance cooling down. However let us suppose we were to consider reversing the experiment, that we wished to compare the behaviour of two liquids as you warmed them up. The success of the experiment will depend on whether you can CONTROL all the conditions in the experiment. Let us consider this point more carefully. What we are interested in is whether water will warm up more quickly than another liquid. Now obviously if we were to take twice the amount of water as the other liquid then it would be an unfair test, since we are interested in the effect of the type of substance and not the amount of substance. So in planning our experiment we would take equal weights of the two liquids. In doing so we would have CONTROLLED the effect of the weight of the substance used during thc experiment.

So in designing the experiment you must decide what unwanted factors might affect the rates at which the two substances increase in temperature, and take steps to control them.

In the space below describe an experiment you could perform to see whether water absorbs heat faster or slower than another liquid.

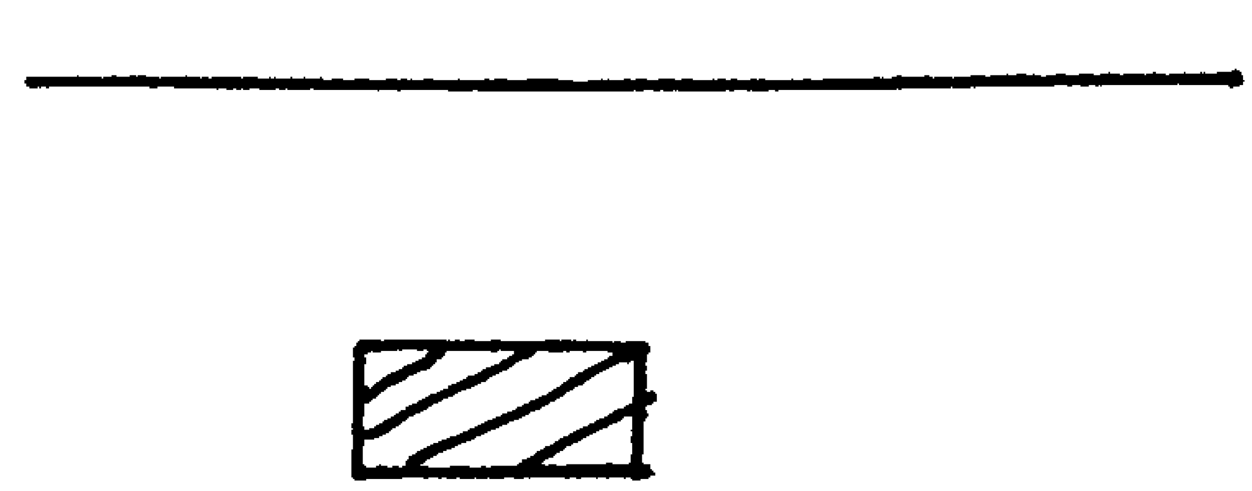
III. Afloat at Sea - Or Under It!

For many Newfoundlanders the ability of boats to float and travel on water is an essential part of their lives. Although we may use boats for travel, work or recreation, the fact that they stay afloat is something we take for granted. Yet people who design and build boats must have a knowledge of one of the oldest principles of science. In this unit we will consider this principle and some other factors which help explain our ability to stay afloat.

Staying Afloat

You are all aware that some objects float while others sink. Whether an object floats or sinks is a result of the forces that act on the object. You are provided with three different objects which float. Try pushing each of them in turn to the bottom of a container of water. Do you experience any force preventing you from pushing the object to the bottom? Does each object require the same amount of effort to push it to the bottom?

Below is a small diagram of an object immersed in a liquid in which it floats. Mark on the diagram with arrows the two forces which act on it.



Take a candle and push a nail into the bottom of it. This will enable it to float in an upright position. Fill a narrow glass container, a 250 ml measuring cylinder is ideal if it is available, with sufficient water to float the candle. Care should be taken to ensure that the candle flame will not be close to the glass when the candle is floated. Mark the position of the water level on the outside of the container. Float the candle in the water. What happens to the water level? Why?

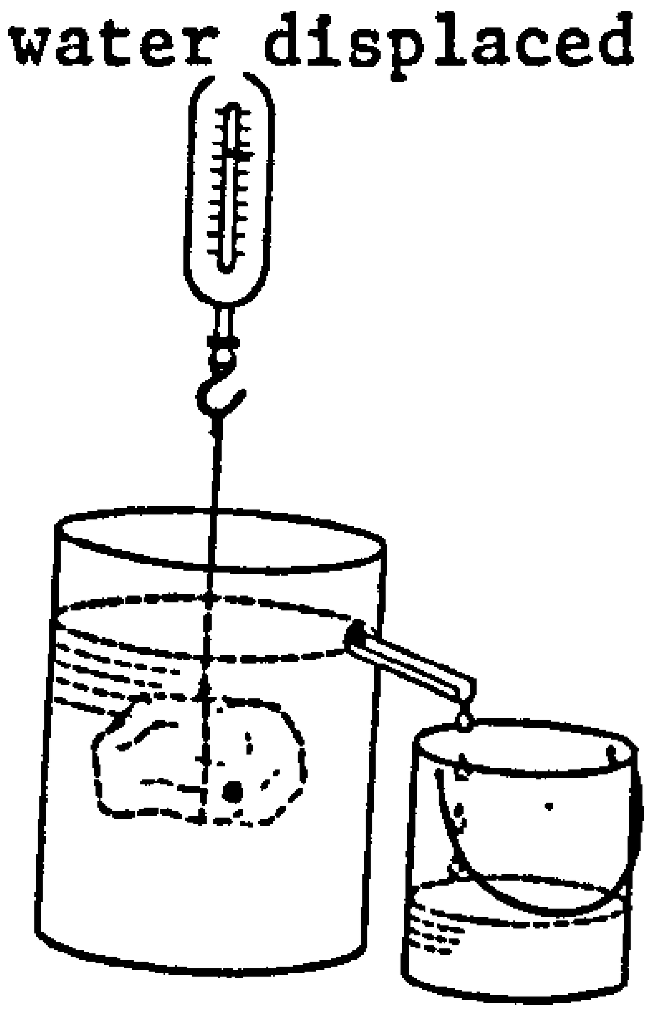
Light the candle, and allow it to burn. What happens to the level of the water as the candle burns?

What connection does there appear to be between the weight of the candle, (remember it loses weight as it burns) and the amount of water displaced?

In this next exercise we are going to investigate more carefully some of the observations you have made so far.

Select a rock which will just fit in the displacement can. Tie a piece of string around the weight and attach it to the spring balance. Record the weight of the rock.

Fill the displacement can with water to the level of the spout. Totally immerse the rock, still suspended from the balance, in the water, and catch the water displaced in a container.



Record the weight of the rock as it is immersed in water.

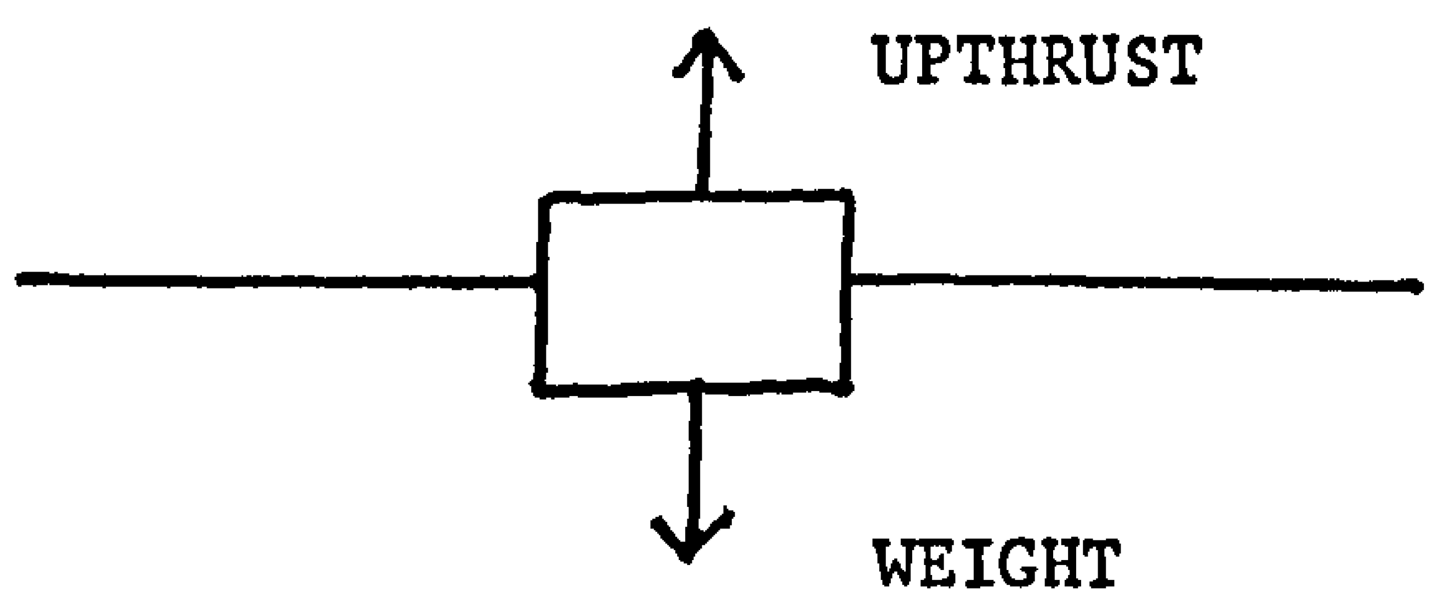
The rock has appeared to lose weight on being immersed in water. How much weight did it appear to lose?

What was the UPTHRUST on the rock?

When the rock was immersed in water it displaced some water which you collected. Determine the weight of the water displaced by the rock. How does it compare to the UPTHRUST on the rock? Compare your results to the other members of the class, do your observations appear to agree with theirs?

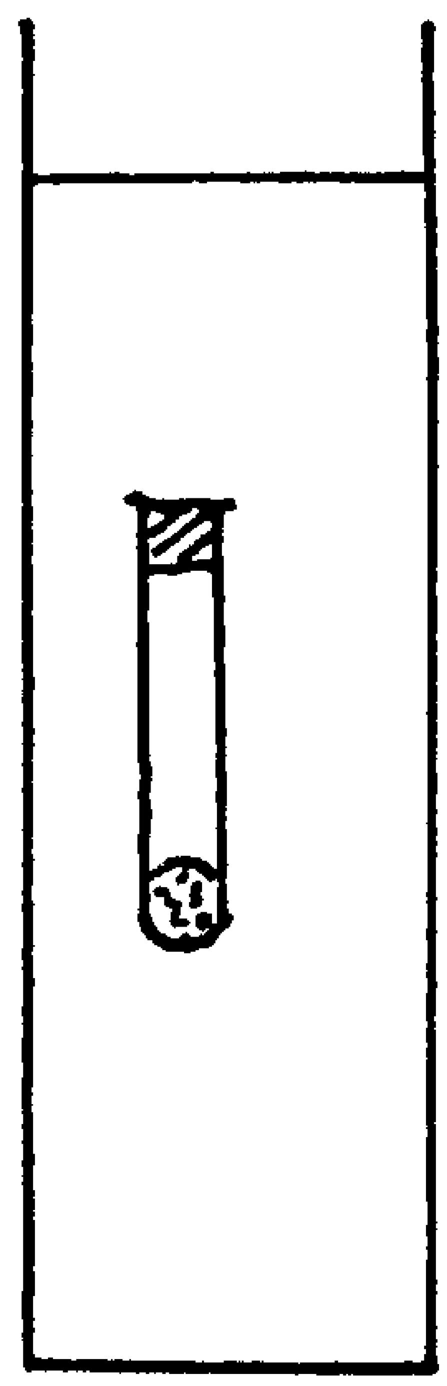
The relationship you have discovered was first stated by Archimedes, and is known as ARCHIMEDES PRINCIPLE.

Let us now consider an object which floats.



In the case of a floating object what must be the relationship between WEIGHT and UPTHRUST?

So far you have considered an object floating in water, let us now consider other liquids. First we must make a "floater". Obtain a test tube with a tight fitting cork stopper. Add enough sand or other material to it so that when it is placed in water it will just float submerged. If you are careful you can adjust it so that it floats in the centre of the container.



Without removing the "floater" from the water add about 10 ml of alcohol to the water and observe what happens. Explain your observations in terms of UPTHRUST and WEIGHT.

Immerse the "floater" in fresh water again, make sure it floats in the centre of the container. This time pour about 10 ml of saturated salt solution into the water. Again explain what happens in terms of UPTHRUST and WEIGHT.

In which liquid, alcohol solution, water, or salt solution does the "floater" experience the greatest UPTHRUST?

The fact that your "floater" experienced a different upthrust in the different solutions was due to the fact that the solutions had different DENSITIES. If you remember Archimedes Principle, the upthrust was equal to the weight of the liquid displaced. Now since your floater displaced the same volume of liquid in each solution it means these volumes had different weights.

You know from common experience that equal volumes of matter do not weigh the same. Thus an old trick question is "Which weighs the heaviest a pound of iron or a pound of feathers?" Of course they both have the same weight, however you know from your everyday lives that the feathers occupy a much greater volume. The relationship between the weight of an object and its volume is the DENSITY of the object.

$$\text{DENSITY} = \frac{\text{MASS}}{\text{VOLUME}}$$

Now note here that we have used the term MASS (The amount of matter present) instead of WEIGHT (The pull an object experiences due to gravity). We often use these two terms without realising that there is a difference between them. For any object the MASS of that object is a constant, however its WEIGHT changes depending on the strength of the pull of gravity. You have seen pictures of astronauts jumping around on the moon, they are able to do so since their WEIGHT is less than on Earth. The pull of gravity on the Moon being smaller than on Earth. However the MASS of the astronaut is the same in both places. The difference between the two is unimportant for us as long as we consider objects on the Earth's surface. We will consider the two terms to be the same for the time being, and also the units in which they are measured the same.

Assignment:-

1. Water has a density of 1 gram per ml. What volume would 25 grams occupy?

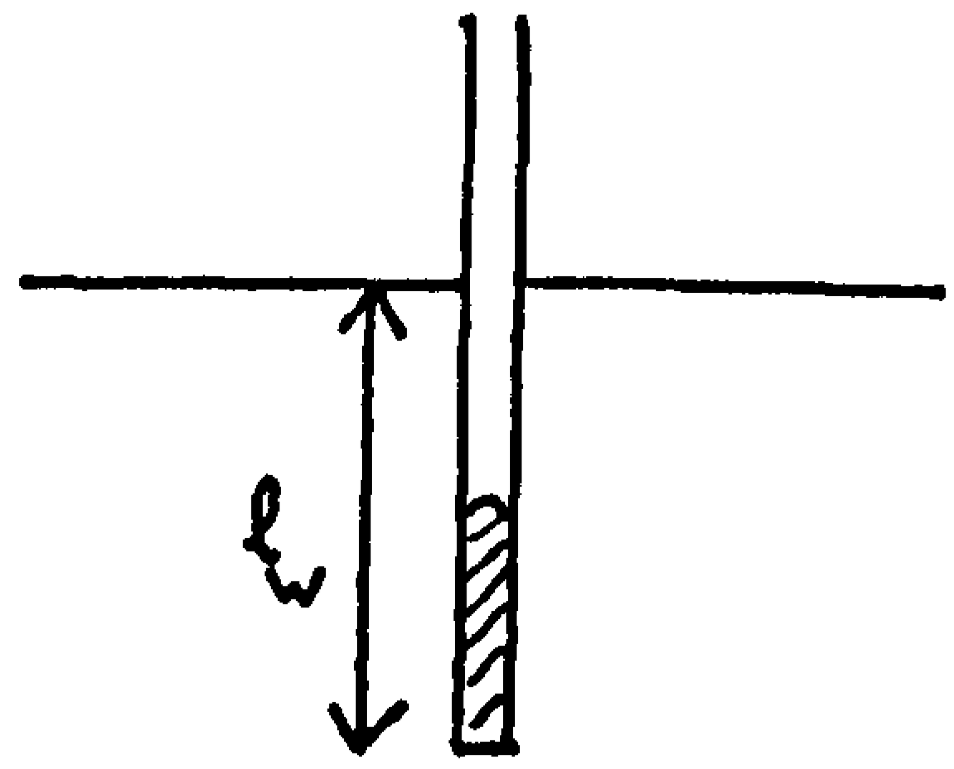
2. John weighs 50.3 kilograms. If his volume is 50.0 litres, what is his density?

3. Legend has it that Archimedes was given a problem to solve. He was asked to determine whether a crown has made of pure gold. He obviously could not cut it up to examine it, as that would destroy the crown. How do you think he solved the problem?

Density of Seawater

Let us now return to the problem of why an object floats. You have seen that in order for it to float it must have an UPTHRUST acting on it equal to its WEIGHT. The amount of UPTHRUST will depend on the weight of the liquid the body displaces. Thus a body will displace a greater volume of a less dense liquid than it will in floating in a more dense liquid. We can use this idea to make a simple instrument with which to measure the density of a liquid.

Take a drinking straw and seal one end by dipping in wax. Add some lead shot or sand so that it floats upright in water.



Mark the position of the water line. Now float the straw in your unknown liquid. Again mark the position of the liquid line. Since the weight of the straw stays the same the weight of the liquid displaced each time is equal.

weight of water displaced = weight of liquid displaced

vol. of water displ. x density of water = vol. of liquid x density of liquid

$$\frac{\text{Density of Liquid}}{\text{Density of water}} = \frac{\text{Volume of water displaced}}{\text{Volume of liquid displaced}}$$

But the volume of the liquid = length of straw immersed x area of cross section of straw

$$\frac{\text{Density of liquid}}{\text{Density of water}} = \frac{\ell w}{\ell 1}$$

Thus by measuring the length of the straw immersed each time you are able to calculate the ratio of the densities of the liquids. If you know the density of water is 1 gram/ml, then you can calculate the density of the liquid.

However we usually quote the value of the ratio of the densities. This value is known as the SPECIFIC GRAVITY of the liquid.

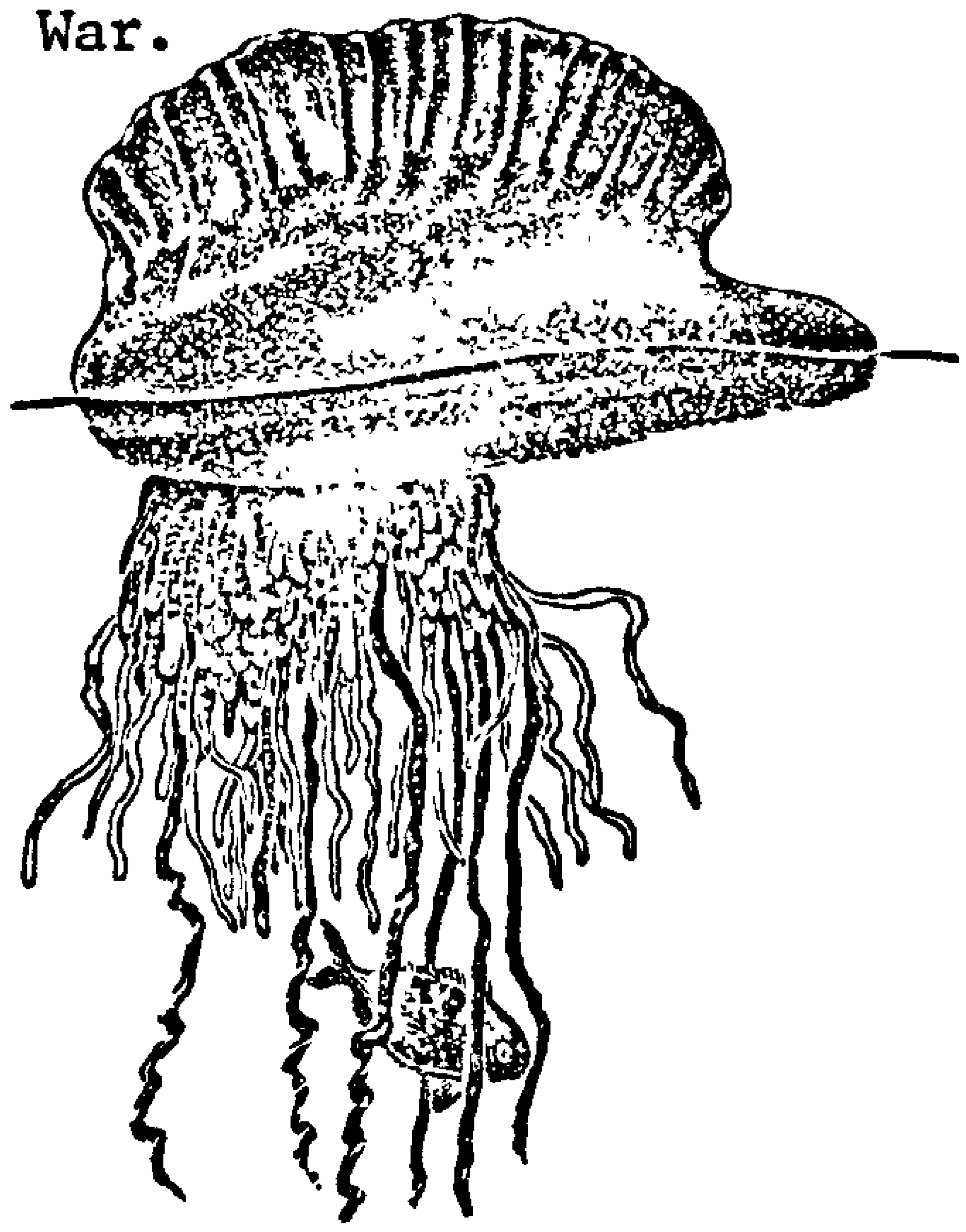
$$\text{SPECIFIC GRAVITY} = \frac{\text{Density of Liquid}}{\text{Density of water}}$$

When you have constructed your hydrometer use it to investigate how the SPECIFIC GRAVITY of a salt solution changes with Salt Concentration. Describe your experiment below, and record your data and conclusions.
How does the density of seawater (SALINITY = 35) compare to pure water?

So far we have considered why an object floats and we have seen that it depends on the upthrust that acts upon it. If an object is immersed in a liquid whose density is greater than that of an object, it will float. However many boats are made of steel which is considerably more dense than seawater. The boat designer however designs his boat so that it displaces a large volume of seawater. The boat thus experiences a large upthrust and can float. You can follow this idea very easily by taking a ball of plasticine, which sinks as it is more dense than water. However, you can easily make it into a boat shape which will float although its weight remains the same. In fact the weight of a ship is usually termed its DISPLACEMENT.

<u>Adaptations for Staying Afloat</u>

Many organisms that live in the sea show adaptations which allow them to float. Among the most obvious are those which have developed air sacs. An air sac increases the volume of the animal while its mass remains the same, thus its density is lower. The most spectacular example is the Portugese Man of War.

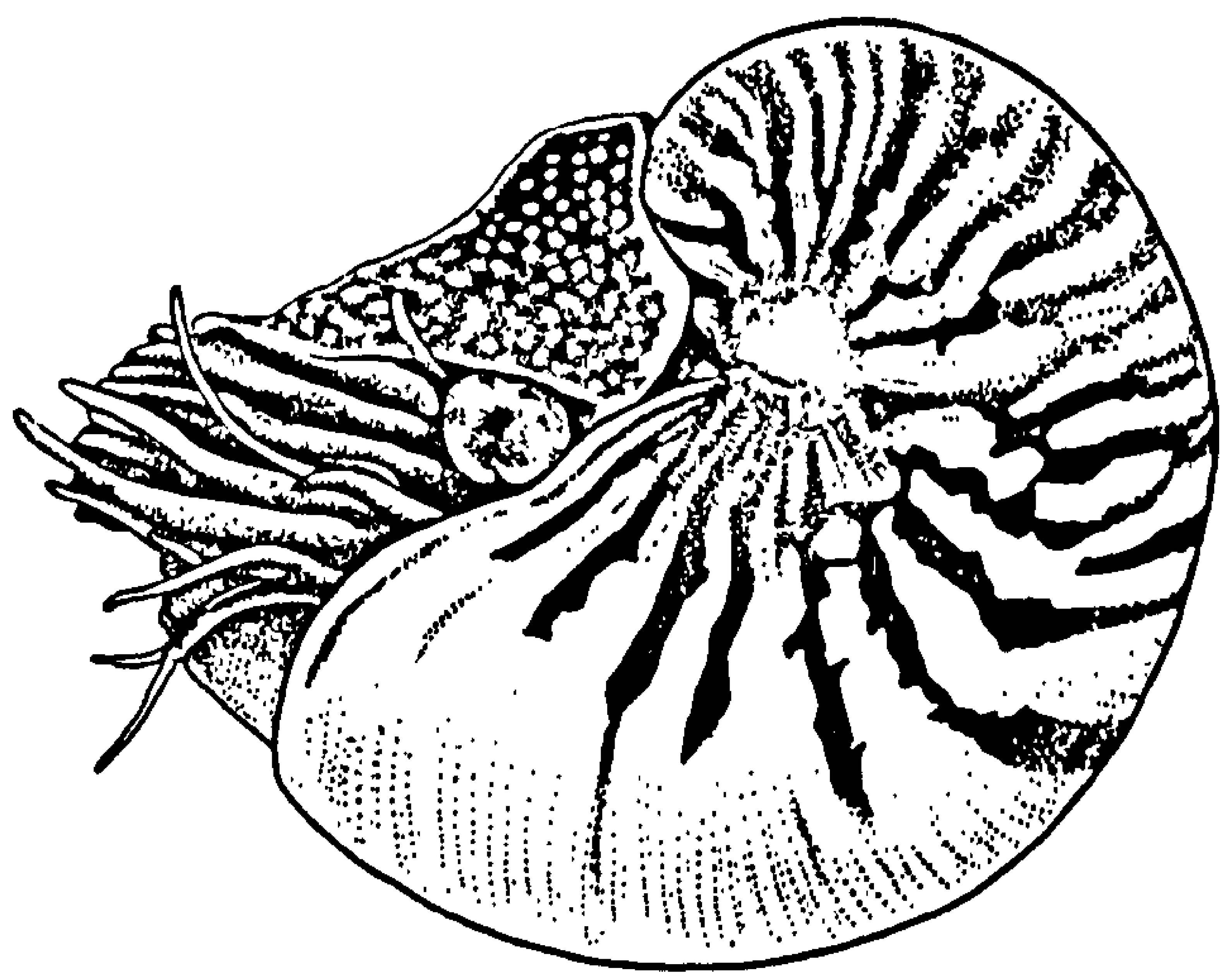


The air sac floats on the surface, while its tentacles trail below it. The tentacles in fact may be twenty to thirty feet long, and can inflict a poisonous sting on animals that they come in contact with. Some human fatalities have been caused by contact with this animal. Some seaweeds also show a similar adaptation with air sacs to keep them afloat.

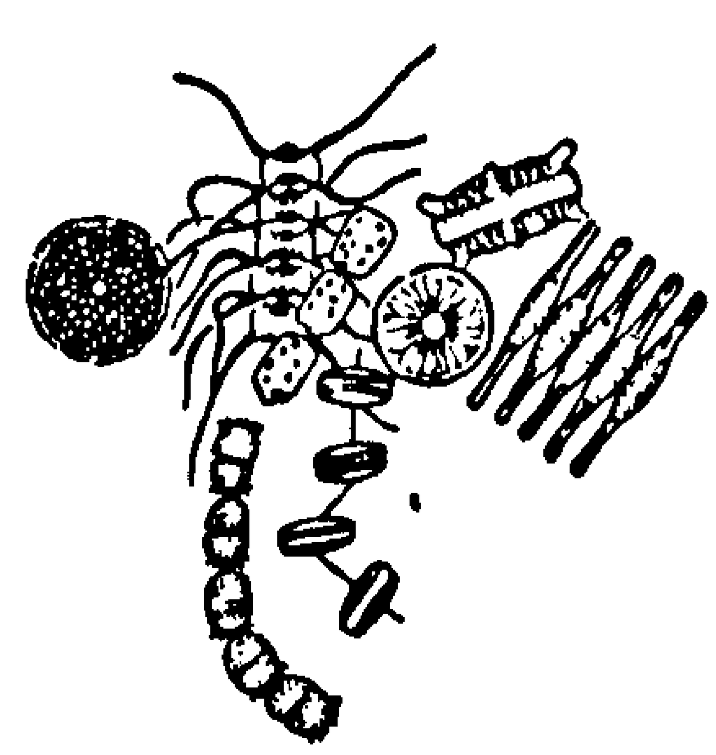
Some fish solve the flo tation problem with a swim bladder. This sac contains gas which helps to counteract the weight of the fish.

Some fish such as sharks do not have swim bladders and have to swim continually to stay afloat.

Some shell fish such as the Nautilus have sections of their shells filled with gas to make them buoyant.



On other adaptation shown by organisms that must be able to float, are those found in plankton which float in the surface layers of the sea. Some of them contain drops of oil which is less dense than water. Others have shapes which give them an increased resistance to sinking. An organism which has a shape which gives it a greater surface area will not sink so easily as one with a more compact shape.



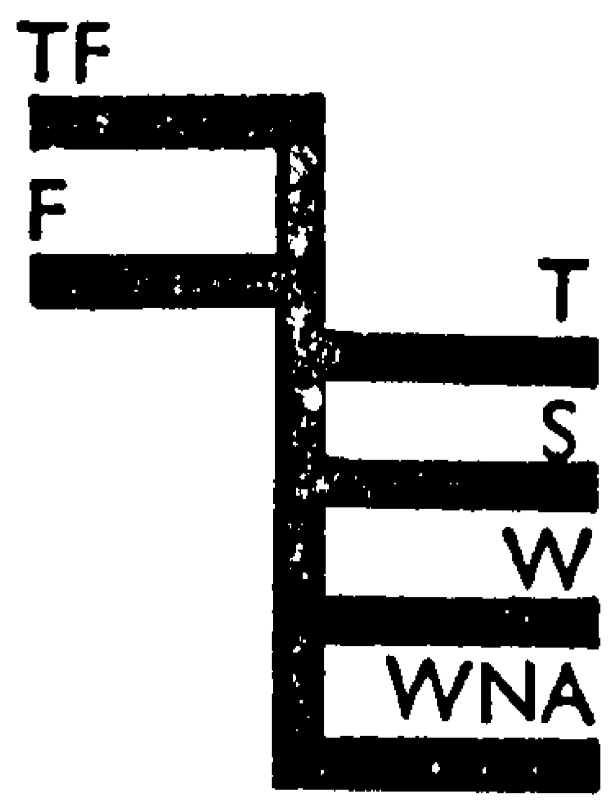
Assignment:-

1. Float an egg first in fresh water and then in salt water. What happens? Explain.

2. Explain why we often say it is easier to swim in salt water than fresh water.

3. Explain why an iceberg floats only partially submerged.

4. The following marks are seen on the sides of ocean going vessels.



Find out what they stand for, and why they are there. Why is there a number of different lines instead of just one?

Project:-

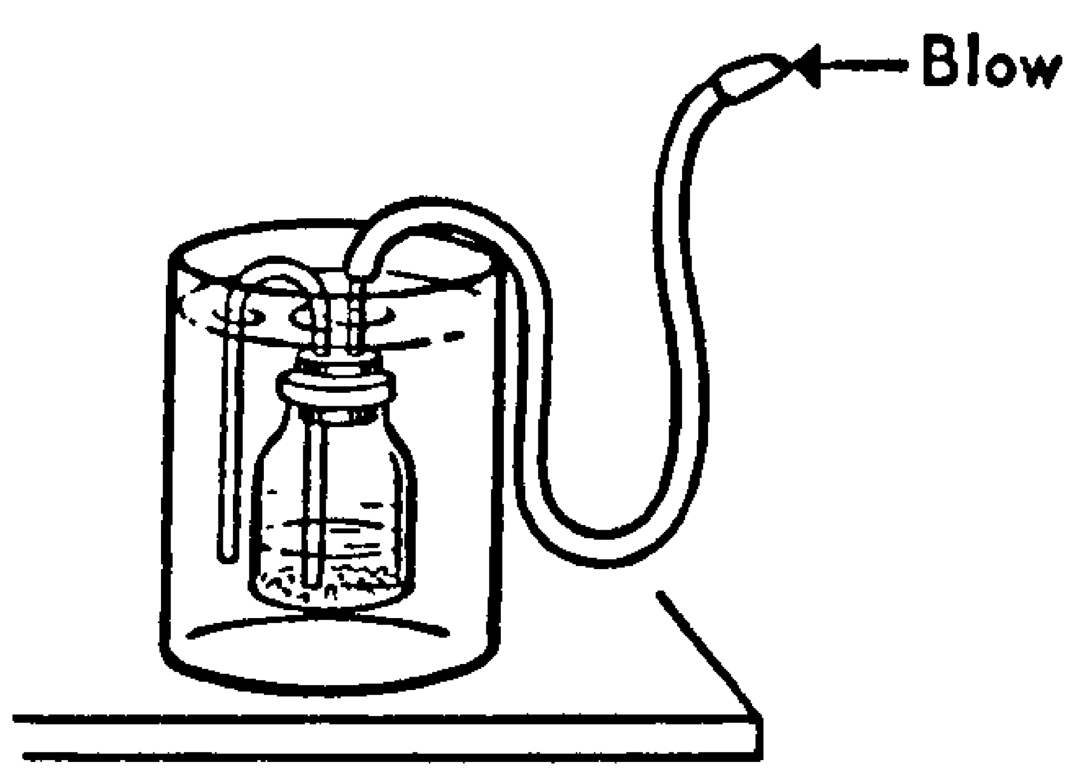
1. A submarine has to be able to move up and down as required. In order to do so it must be able to adjust its density as required. The following project taken from the U.N.E.S.C.O. Source book for science enables you to understand the principle of its operation.

Place pieces of iron or rocks in the bottom of a small wide-mouth bottle and pour a little melted paraffin on them to fasten them down so that the bottle will float in an upright position. Insert a two-hole stopper. In one hole place a U-shaped length of glass tubing which extends to the bottom of the bottle. In the other hole put a short length of glass tube and a rubber tube. Set the bottle in a large vessel of water.

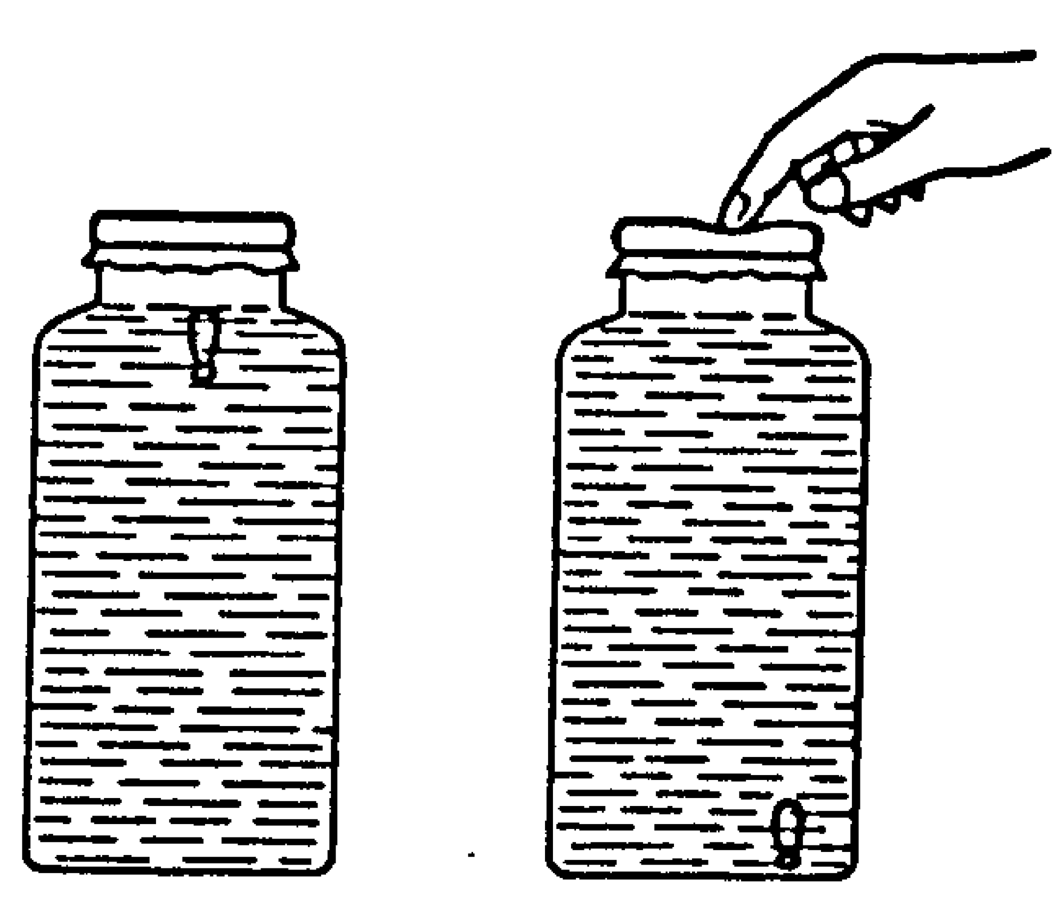
Withdraw some air by sucking on the rubber tube and water will siphon into the bottle until the bottle sinks. The bottle may be made to rise by blowing out part of the water.

Actually, submarine engineers adjust the buoyancy of the submarine to that of the water and then use the elevators to dive or climb. To remain at the surface they will 'blow' the tanks with surface air after rising. The use of compressed air to empty the tanks is not practical while the submarine is submerged.

The device also illustrates the principle of the tanks or pontoons used to lift sunken ships. Fasten a weight to the bottle, sink both in water and lift the weight by blowing air into the bottle.



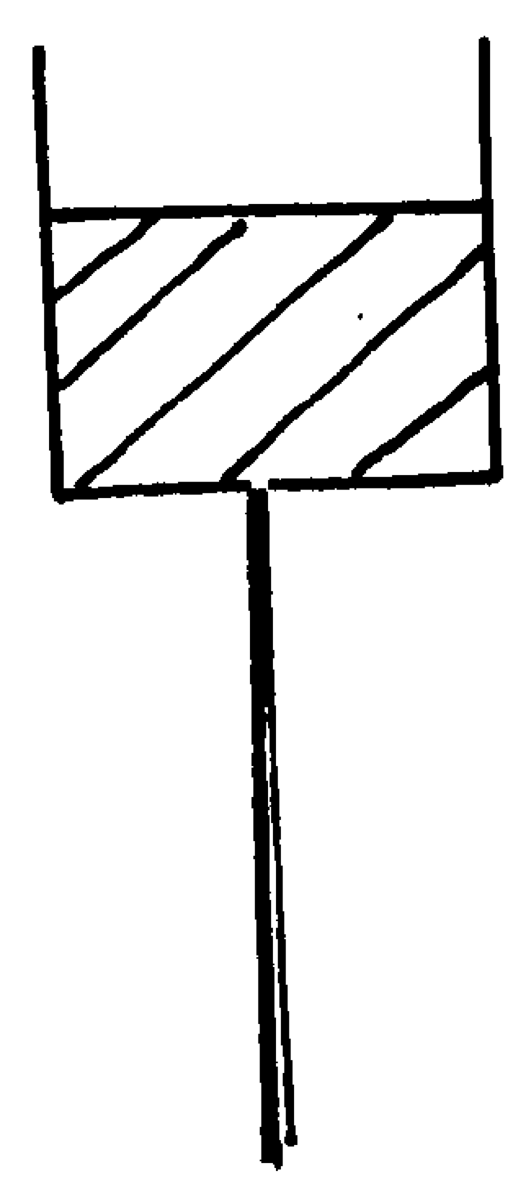
2. Great fun can be had with a Cartesian Diver. You require a small test tube, pill container or other container which is open at one end. The rubber bulb from an eye dropper works very well. Trap a little air in the container so that it just floats submerged in a tall glass container. Considerable adjustment of the air trapped inside is required. Cover the mouth of the container with a thin piece of rubber stretched tight and firmly tied. By pressing on the rubber the diver will sink. With a little practice and a smooth-talking presentation you can convince your friends that you can make the diver sink or rise at will. The movement of your hand on top of the container being so small as not to be noticed.



Moving Along

In the last section we considered the basic reasons why a boat floats. In this next section we are going to look at another property of water we often take for granted. Water is a liquid which flows very easily. It does not behave like molasses or motor oil which flow slowly. The measure of a fluids ability to flow is its VISCOSITY. Thus water has a low viscosity compared to molasses. If you have ever stirred molasses or cake batter, you will have "felt" the viscosity of a liquid. Glass is classed by scientists as a supercooled liquid, and actually flows very slowly. An old sheet of glass in a window is usually slightly thicker at the bottom than at the top of the sheet. As glass has a very high viscosity it flows downhill very slowly, and as a result the bottom of the sheet is thicker than the top. This often results in the view through the window appearing bent.

To measure the viscosity of a liquid requires fairly complicated apparatus. However, we can use a very simple device to compare the viscosities of two liquids. Take a container such as a tin can, or an ice cream can and make a small hole with a nail. Pour 500 ml of water into the can, keeping your finger over the hole. Take your finger away and time how long it takes for the water to flow out. Stop your timing when the stream of water first breaks. Do not wait for the last few drops to drain out.



Use your simple viscometer to compare the viscosity of water to the viscosity of saturated salt solution. Which is the most viscous? How much salt solution should you use? Why?

Seawater has a viscosity only slightly different from pure water, both have a low viscosity. Your teacher will provide you with a more viscous liquid. Design an experiment to investigate how its viscosity changes with temperature. Record your procedure results, and conclusions below.

We have seen that the high density and low viscosity of seawater make the sea's surface suitable for travelling. The high density enabling ships to float, while the low viscosity means they can move through the water easily. However it is the low viscosity of water which enable large waves to form and be a danger to seafarers. In the next section we will find out something about waves.

IV. RHYTHMS OF THE SEA

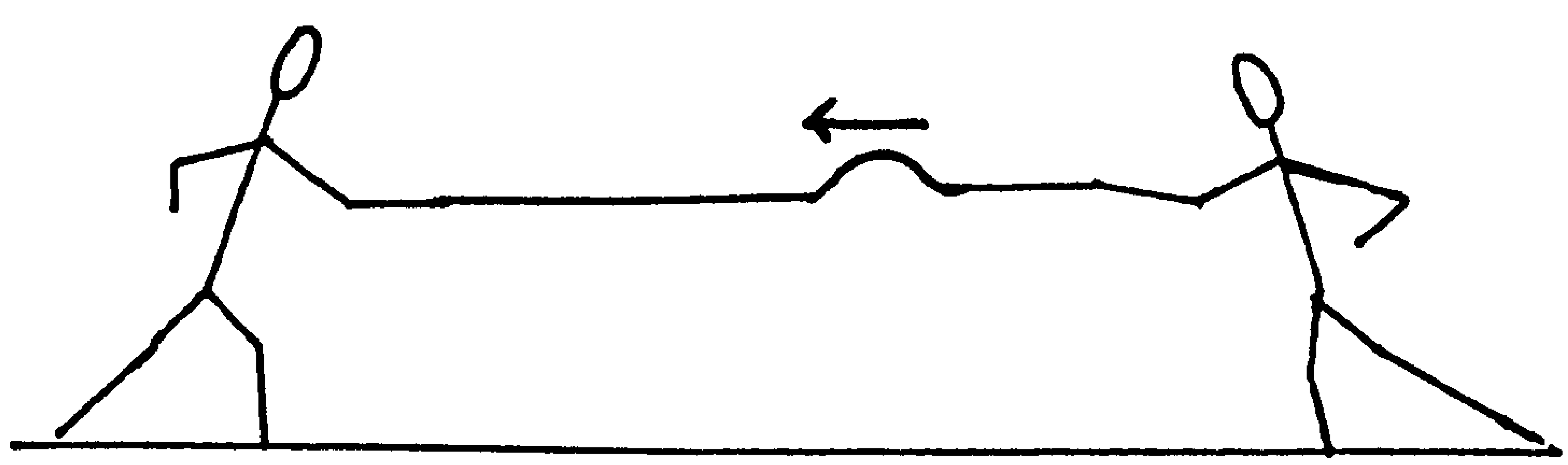
If you stand on a beach and watch the oceans, you cannot help being fascinated by the movement and power of the sea. Breaking waves release their energy against the shoreline, as they pound out their ceaseless rhythm. There is also another more gentle rhythm to the sea, the slow rise and fall of the tides. A rhythm that has fascinated man through the ages. In this next unit we are going to consider these two rhythms of the sea, the tides and waves.

Waves - The Energy Carrier

In this section we will consider some of the simpler behaviours of waves. Although we will consider mainly ocean waves, it is important to realise that the study of waves is fundamental to many branches of science. Many things that we study in science are waves, e.g. sound, light, radio, and many of the ideas that we meet in this section apply to these topics, as well as to ocean waves.

It takes very little observation to realize that waves transmit energy. The pounding of the waves continually alters our shoreline, wearing away rocks and cliffs with apparent ease.

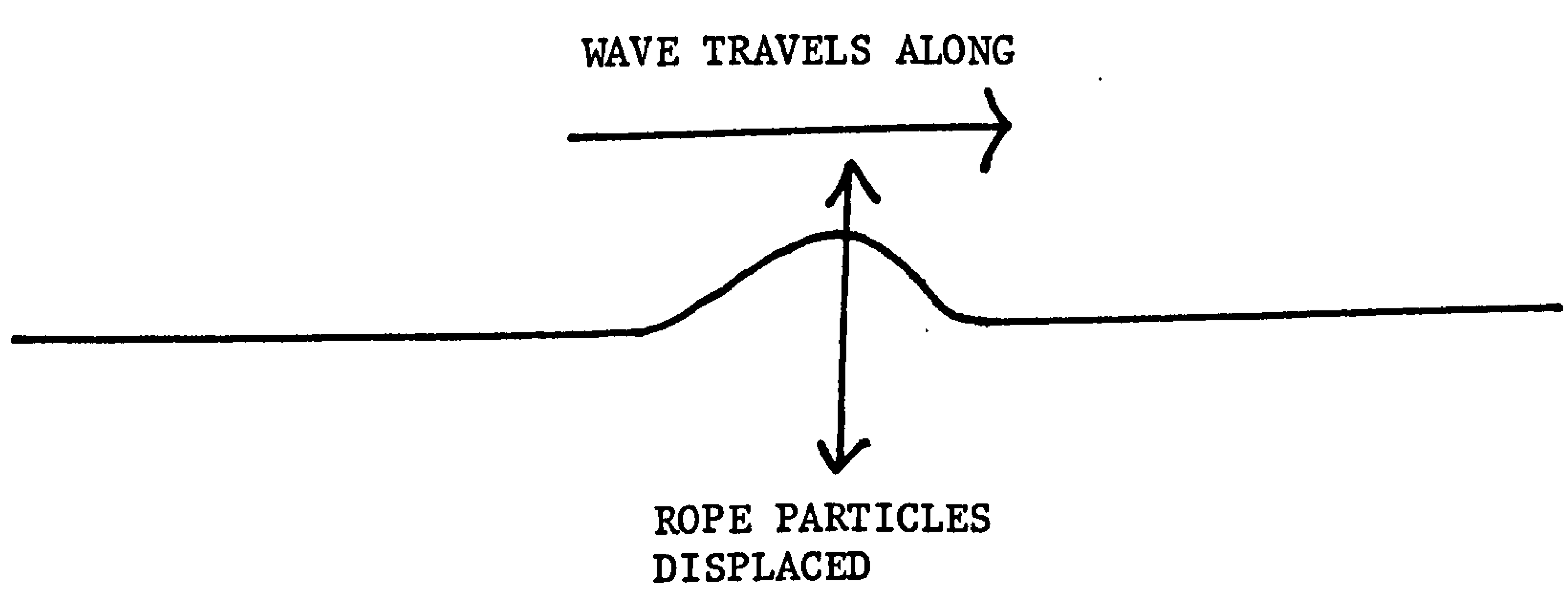
Take a length of rope or rubber tubing, the thicker the better, and stretch it out between you and your partner. Take it in turns to shake a pulse to each other.



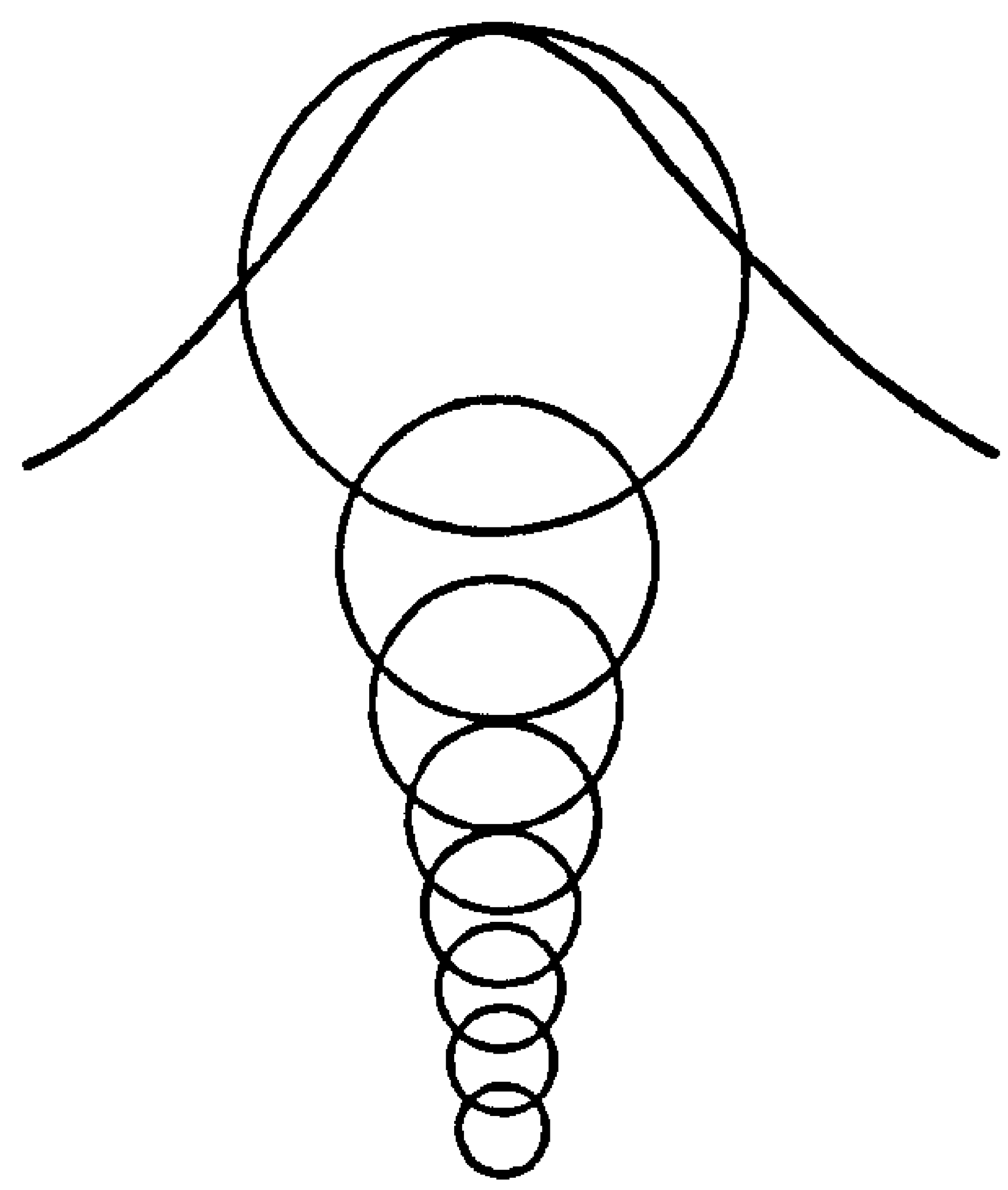
As your partner shakes the pulse try to keep your arm still. You will find no matter how hard you try your wrist will move, if only a little bit. The energy your partner used to produce his wave travels along the rope, and moves your hand.

Float a cork in a large container of water. Strike the surface of the water. As the waves spread out and strike the cork observe the motion of the cork. Does the cork move in the direction that the wave travels?

It is important to realize that the wave passes through the water. The water particles do not travel along with the wave. Just as the wave passed along the rope without the particles of the rope moving with it. In fact in the rope the particles move at right angles to the direction of travel of the wave.



In a water wave however the water particles do not simply move up and down they move in orbits.



The further below the surface the smaller is the orbit of the water particles.

Although waves come in all sizes, the same terms are applied to all of them.

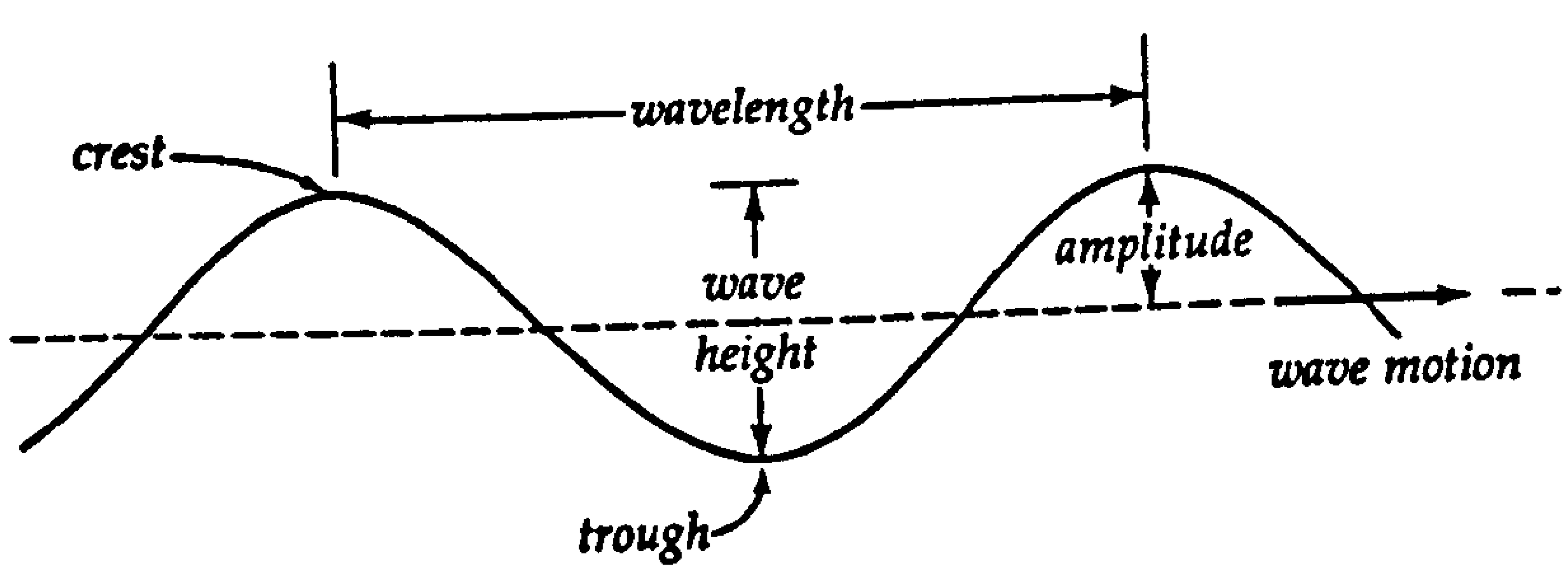
a. WAVELENGTH:- Is the length of the wave, measured between any two equivalent points, e.g. from crest to crest.

b. PERIOD:- Is the time it takes for one complete wave to pass a point.

c. FREQUENCY:- Is the number of waves which pass a point in a given time.

d. AMPLITUDE:- Is the distance the wave is displaced above or below normal surface level.

e. HEIGHT:- Is the vertical distance between trough and crest. It is twice the amplitude.



The velocity of travel of a wave = frequency x wavelength

$$v = f \times 1$$

Thus, the speed of travel of a wave with a wavelength of 2 metres and a frequency of 10 waves/second

= 2 x 10 metres/second

= 20 metres per second

The period of the wave is the time for one wave to pass

$$= \frac{1}{\text{frequency}}$$

$$= \frac{1}{10} = 0.1 \text{ seconds}$$

Assignment:-

1. You are observing a series of waves passing you from a boat at anchor. 30 waves pass you in 10 seconds. What is the PERIOD of the wave.

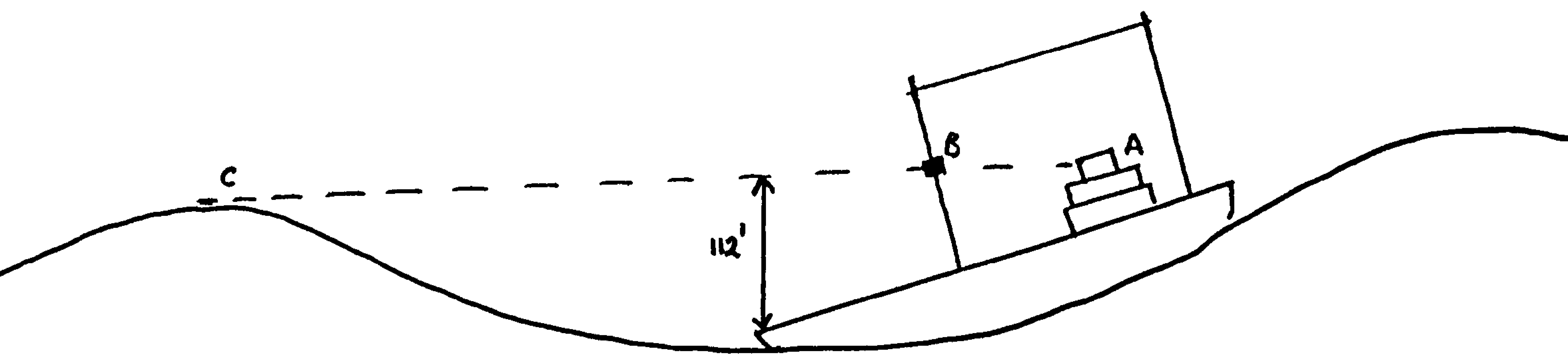
2. A group of waves pass a point, their period is 0.2 seconds. If their wavelength is 1.5 metres at what speed are they travelling?

3. A musical note has a frequency of 175 waves per second. If sound travels at a speed of 350 metres per second, what is the wavelength of the note?

Most waves one observes an the sea are caused by the wind. The friction of the wind soon causes ripples, then waves to form. The size of the waves depends on three factors.

a. The strength of the wind.
b. The length of time for which it blows.
c. The "fetch", which is the length of the stretch of open water over which the wind blows.

It is difficult to determine the exact height of large waves. However it is generally agreed that the wave reported by Lieutenant Commander R. P. Whitemarsh on February 7, 1933 is the most accurate estimate of a large wave. The U.S.S. Rampano was going from Manila to San Diego. The ship experienced a disturbance in which the wind blew at 60 m.p.h. for several days. The officer on the bridge, A, reported that as he looked towards the stern he saw the crow's-nest, B, on the mainmast in his line of sight to the crest of waves, C, astern, which had just come in line with the horizon. From the size of the ship it was possible to estimate the size of the wave. The diagram shows how the height of the wave was estimated at 112 feet.



The period of these giant waves was timed at 14.8 seconds, and their speed was 60 miles per hour, how far apart was one crest from another?

The force exerted by waves in a storm can be enormous. There are many stories of the damage caused by storms, but one of the most amazing accounts is of two storms which struck Wick, Scotland in the 1870's. In 1872 a storm tore loose a concrete breakwater and its foundation and deposited them in the sea. The weight of the breakwater was 1350 tons. The designer watched the destruction of his breakwater with amazement. He redesigned the breakwater so that it was over twice the weight of the previous one. This heavier breakwater suffered the same way in a storm three years later. It was calculated that during the storm, the waves exerted a force of 3 tons per square foot.

Most of us have stood and watched waves breaking as they approach the shore. It is as waves break that we realize the large amount of energy carried by them. Waves break because the ocean becomes shallower as the wave moves toward the shore. As the wave approaches the shore the shallow water causes the speed of the wave to decrease and the wavelength to decrease. The waves begin to crowd against each other and will eventually break.

A simple guide as to when a wave breaks is as follows. A wave will break when the depth of water under the wave is four-thirds the height of the wave. Thus a 3 foot wave will break when the water is four feet deep.

Breaking waves, and wavelengths are not studied simply out of curiosity, they can often provide a great deal of information. During World War II, information about beaches was obtained by photographing, waves breaking on the shore, and analysing the pictures. Thus scientists were able to calculate the slope and nature of the ocean floor, and this information was a great help when planning how to land men on the beach during an invasion.

Tidal Waves

Although the majority of waves that we see in the ocean are the result of the wind, waves can result from other causes. The most spectacular are tidal waves. However it should be noted that tidal waves are not caused by tides, and because of this they are now more usually called TSUNAMIS, or SEISMIC SEAWAVES. Tsunamis are usually the result of some rapid movement of the Earth's crust. The most common causes are earthquakes or underwater avalanches. These events produce waves with very long periods, often 15 minutes, and wavelengths up to 150 miles. These waves also travel across the ocean at very high speeds up to 500 m.p.h. From an earthquake three or four waves may be produced. In the open ocean the waves may have a height of only 2 or 3 feet, however, as they approach shore they pile up and often grow as high as 100 feet. The resulting damage can be costly, and many lives have been lost as a result of tsunamis.

Although Newfoundland is not commonly affected by earthquakes and tsunamis, in November 1929 the province was struck by a tsunami.

The worst damage was suffered by communities on the Burin peninsula . The following accounts are taken from the Newfoundland chronicle of December 1929.

Earthquake and Tidal Wave Disaster.

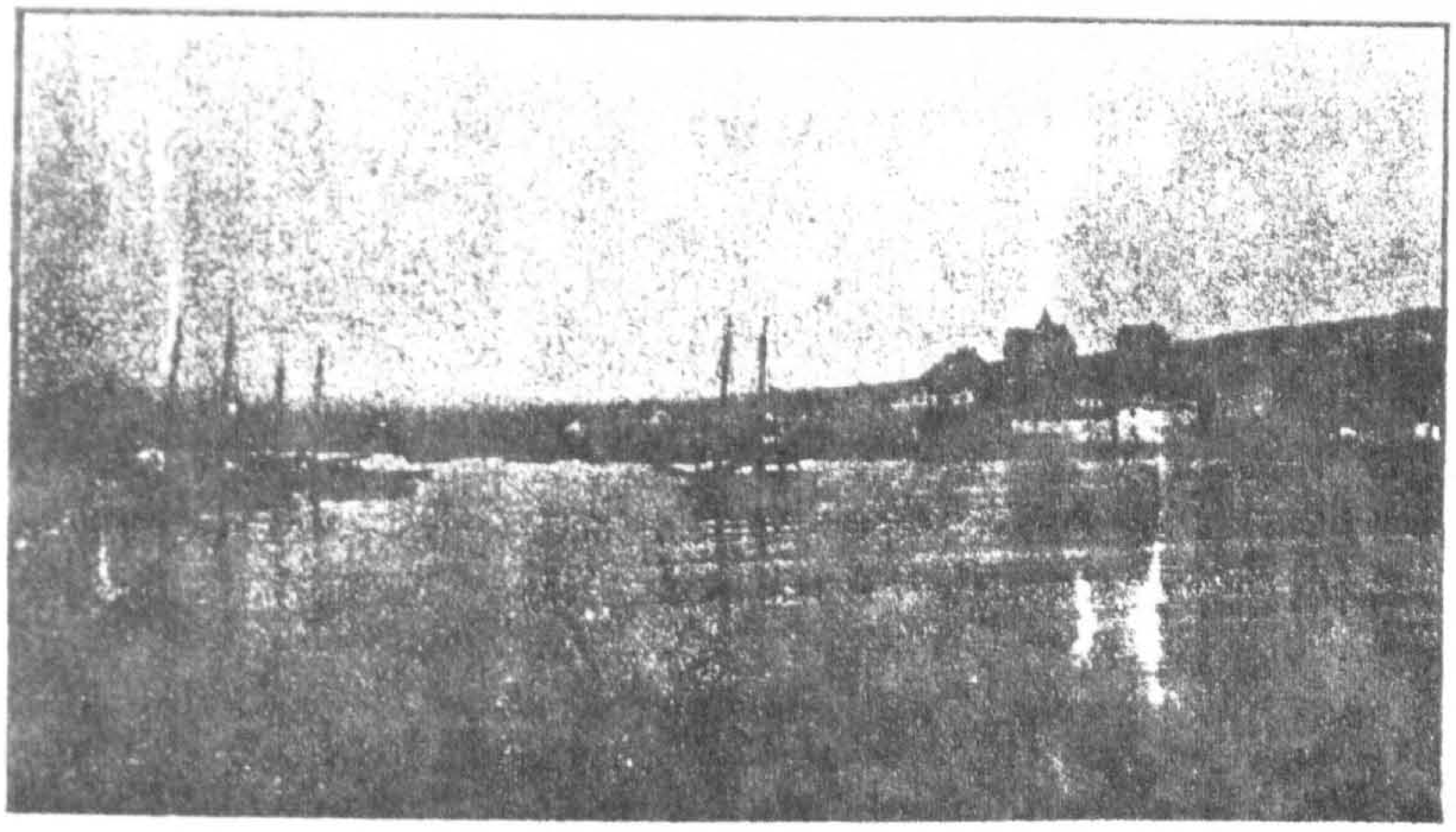
On the 18th of November Newfoundland had the unusual experience of an earthquake and tidal wave visitation that did tremendous damage on the Burin Peninsula. In the area between Rock Harbour and Lamaline inclusive, 27 lives were lost, and houses, boats and other property to the value of a million and a quarter dollars were destroyed. Living within the section mentioned is a total population of ten thousand people. Practically all of them were either business men or fishermen. Both classes were very heavily hit. The business men lost their stores and stocks of goods. The fishermen lost virtually everything required for the prosecution of our staple industry.

Owing to the effects of the earthquake the telegraph lines were down between the affected area and St. John's; and it was not until three days afterwards that information of the terrible catastrophe reached St. John's, being wirelessed to the city from the coastal steamer Portia. The Government immediately prepared an expedition to proceed to the scene. The steamer Meigle was got in readiness, a Staff of Doctors and Nurses secured, and Medical supplies, together with a large quantity of food and building material, was rushed on board. The situation was handled so promptly, and with such energy, that within five hours after the first news of the disaster reached St. John's the Meigle was out the Narrows proceeding on her errand of mercy and relief. Less than 24 hours later she was tied up to the Government wharf at Burin, a Local Relief Committee had been formed, headed by Magistrate Hollett, and relief supplies were being discharged and distributed to the destitute.

During the survey the members of the expedition by the str. Meigle saw some terrible scenes of suffering and destruction. Prosperous settlements like Rock Harbour, Port au Bras, St. Lawrence, Taylor's Bay, Point au Gaul and Lamaline had been terribly affected.

In practically all of these places the foreshore had been denuded of buildings, boats and property of all kinds, and scores of dwelling houses with their whole contents had been either swept to sea or smashed to kindling wood by the terrible force of the tidal wave that succeeded the earthquake. Heart rending scenes of bereavement were witnessed. In some cases whole families had been wiped out, and in others only one or two members survived the catastrophe. A great deal of suffering had been caused by exposure or shock or injuries, and many people were entirely destitute. The Medical and Nursing Staff on the Meigle were promptly on the scene taking care of the sick and injured, while the Relief Committee landed from the ship, and cargoes and supplies of coal comandeered on the Coast, did much to alleviate the destitution that had prevailed.

The people of the stricken section, aware of their isolation through the interruption of the telegraph services, were most agreeably surprised by the appearance of the Government Relief Ship and were loud in their praises of the prompt and practical nature of the relief efforts instituted by Sir Richard Squires, Prime Minister, and his Colleagues. The expedition included two Members of the Executive Government, Hon. Dr. Mosdell, Chairman of the Board of Health, and Hon. Dr. Campbell, with Mr. H. B. C. Lake, M.H.A., Minister of Marine and Fisheries, and Mr. P. T. Fudge, M.H.A., for the District of Hermitage.



ST. LAWRENCE—BEFORE THE DISASTER.

The expedition not only relieved sickness, suffering and destitution, but instituted a careful and detailed survey of property and other losses on the Burin Peninsula. Committees were formed to take care of the situation temporarily until a permanent oranization had been created for this purpose. At Lamaline the Chairman of the Local Committee was Mr. C. C. Pittman, J.P.; at Lawn, C. Murphy; and at Burin, Magistrate Hollett, ; and at St. Lawrence, Constable Victor Mullet.

Meanwhile a deputation from Burin had visited St. John's to to interest the people of the City and of the Country generally, on the condition and the relief of those who had survived the disaster in the stricken area. Public Meetings were held, with His Excellency the Governor in attendance and as Patron of the movement. A general Committee, the Personel of which is given a little further on in this article, was formed and began the work of collection of funds for relief purposes. A great deal of enthusiasm was manifested in the good work, and when the issue of the QUARTERLY goes to Press, it appears certain that the Citizens Relief Fund will total at least One Hundred Thousand Dollars by the end of the present year. A great many gifts in kind as well as in cash have been received, and Mrs. J. A. Winter did particularly effective work in the collec tion of clothing for distribution throughout the section affected. Magistrates and other prominent citizens throughout the country co-operated with the central committee, and contributions from the Outports are beginning to pour in to the General Fund.

On the return to town of the Government Relief Expedition, an Official Committee was formed to take care of the expenditure of outside contributions that can be handled only through official channels, to continue to survey all property losses and to consider a policy of rehabilitation of the fishermen, so that they can resume their occupation when the next fishing season opens. This Committee consists of Mr. H. B. C. Lake, M.H.A., Chairman; Hon. A. Barnes, Colonial Secretary; and Hons. H. M. Mosdell, and Alexander Campbell, with Mr. George Coen as Secretary, but not a member of the committee.

While the Citizens Committee are vigorously and effectively handling the problem of relief, the official committee of the Government are carefully considering all the ecomomic aspects of the problem created by the destruction caused by the disaster and are recommending to the Government from time to time the restoration of public works and preliminary undertakings in connection with the huge problem of restoration of the Fishermen to an independent working basis. The fullest co-operation exists between the Official Committee of the Government and the Citizens Relief Committee. The Prime Minister, Sir Richard Squires, is honorary President of both bodies, and over-lapping or reduplication of effort is thus avoided.

The British Red Cross and the American Red Cross and big corporations such as The Anglo-Newfoundland Developing Co., The International Power & Paper Co., Buchans Mining Co., Harvey & Co., Bowring Brothers, Ltd., Job Brothers & Co., Ltd., and many others have contributed to the relief funds large amounts ranging from $1,000.00 to $10,000.00, while Newfoundlanders abroad, in various parts of Canada and the United States, are organizing for the relief of their fellow countrymen in distress.

Extracts from the Daily Papers on the Earthquake and Tidal Wave Disaster.

St. Lawrence Resident Describes Monday Night's Horrors.

On Monday evening, November 18th, St. Lawrence was the scene of a dreadful disaster occasioned by a tidal wave which almost entirely destroyed the settlement and wrought much havoc along this section of the Southwest Coast.

At 4.45 a dreadful rumbling noise was heard, accompanied by a violent trembling of the earth which shook each dwelling to its foundation and lasted about five minutes to the horror of everyone.

The Second Tremor.

The people became panic-stricken and many forsook their homes. The excitement was intense and when about two hours later a terrific roaring of the sea was heard, fear struck the hearts of all. A few minutes after, a tremendous wall of water burst into the harbor and swept with irresistible force upon the land, tearing town everything in its way as it rushed along.

Wave After Wave.

The din of roaring waters, of shouting people and the breaking up of buildings was terrifying. Many houses were carried bodily inland for a considerable distance and some of them deposited when the force of the huge wave was spent, whilst many others were broken into splinters. Then, with a mighty roar, the waters receded, carrying with them boats, fishing stages, stores and dwellings. Again and again the dreadful waves rushed in upon the land, each one more destructive than the last.

Sick Carried to Safety.

The frightened people fled in a panic to the higher ground. Many sought refuge around the Church. The Presbytery and Convent were crowded with people as these buildings were high above the waves. It was a pitiable sight to see people carrying their sick to a place of safety, or surrounded by crying children, and shrieking with dismay when some loved one was missing, fearing he had been engulfed by the terrible sea; darkness adding to the awful confusion.

Did Not Dare Go Home.

By ten o'clock the destruction was complete and the waves settled down to a steady, but by no means normal condition. Yet the people feared to return to their home, many spending the night in neighbors' houses, in barns and other places of shelter, but none dared to sleep.

The Sight as Dawn Came.

At dawn next morning sad beyond description was the sight that greeted the wretched people. All their fishing premises, stages, stores, boats, nets and other gear, as well as barns of hay and cattle swept away by the pitiless sea or strewn in fragments upon the shore. Houses, fishing gear, stores and wreckage of all kinds floating upon the still swollen and raging sea. In a blinding storm of wind, sleet and snow men and boys were trying at the risk of their lives to rescue some planks or sticks, the only remnants of their little property which represented their all, the result of their lifelong labor and thrift.

All But Two Stores Destroyed.

All their fishing premises, large and small, with the exception of two stores were destroyed, many of them filled with fish. All the boats and fishing gear were carried off or thrown in a shapeless mass of wreckage upon the shore. Added to this the provisions for the winter: flour, molasses, meat, etc., which were in their stores were also carried off. Several homes were destroyed and the people are reduced to a very pitiable condition. As the fishery this year was a poor one, only the barest necessities of life were procurable and now all is lost.

Priest's Noble Service.

All that terrible night our indefatigable and ever-resourceful pastor—Very Rev. Father Thorne—went amongst the people, calming the panic-stricken and encouraging the terrified and helping those in distress. Next day he busied himself inspiring hope into the depressed people. In the evening he called them together and in a long address he encouraged them to begin the work of reconstruction by saving the wreckage floating on the harbor, pointing out ways and means by which it could be more successfully accomplished and did all he could to relieve the terrible situation.

The erection of the telegraph poles and wires which were swept away was done under his personal supervision. When commuication was established with the neighboring settlements it was learned that Lawn and other places had suffered equally, and that at Point aux Gaul, Port au Bras and Lord's Cove several people were drowned.

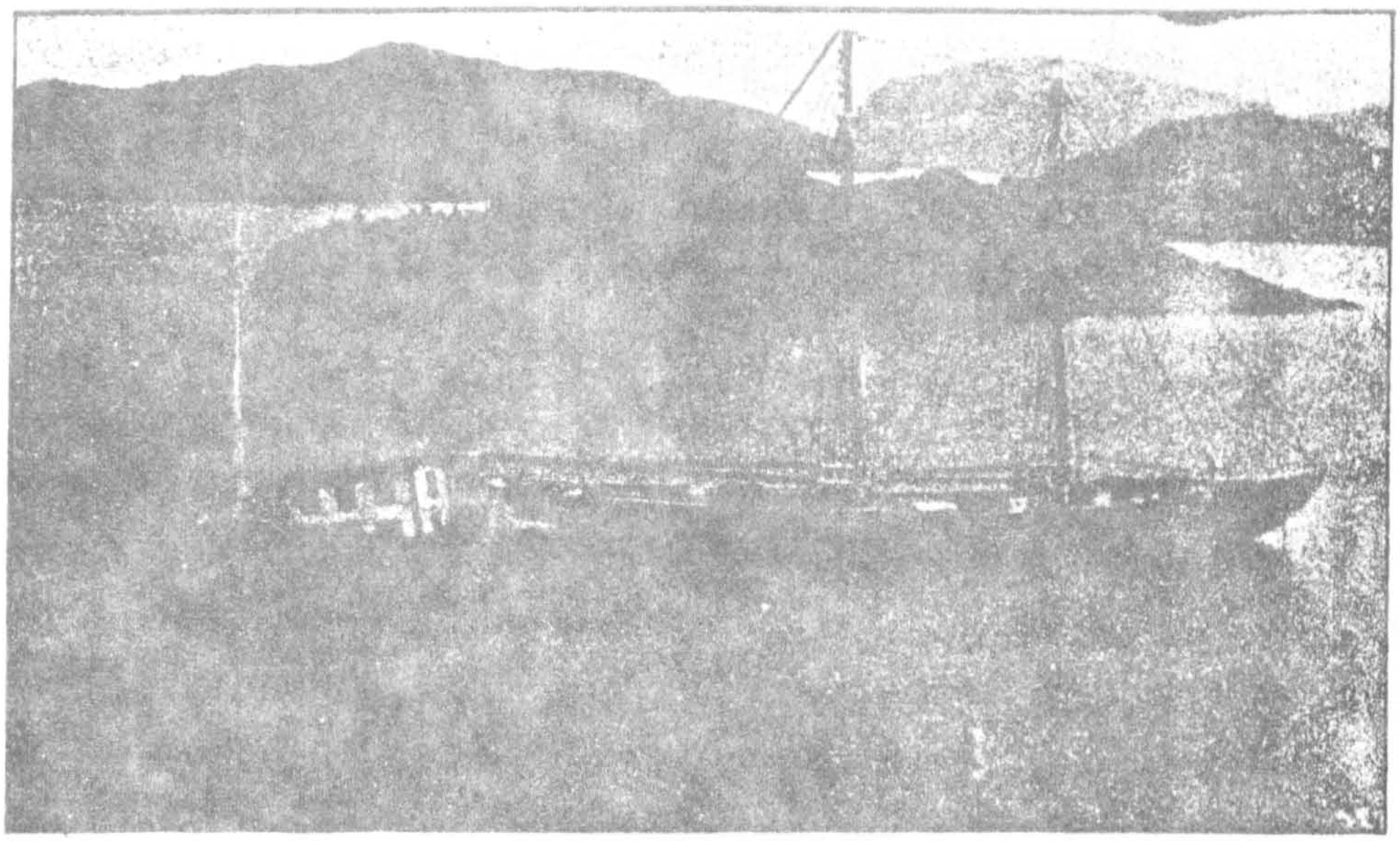
The fact that no lives were lost at St. Lawrence and with the exception of a few bad hurts, no one was seriously injured, is a great cause for thankfulness, and a source of gratification to the poor people in their awful affliction.

The estimated amount of damage and loss is from $150,000 to $250,000.

The Severed Cables.

November's Earthquake Reshaped the Ocean's Floor.

By J. W. Gregory in Nature.



MR. CLARKE'S HOUSE TOWED FROM SEA BY S.S DAISY, AND MOORED AT SHIP COVE, BURIN HARBOR.
Earthquake and Tidal Wave Disaster, November 18, 1929.

THE powerful earthquake south of Newfoundland which on November 18 and 19 of last year broke eleven submarine cables in at least twenty-three places and devastated the southern coast of Newfoundland promises important evidence as to the nature of the submarine canyons off the Atlantic coast of Canada and the United States. The earthquake was obviously of the highest order of intensity at its centers, for it overthrew chimneys, and was therefore of the order of over No. 7 on the Rossi-Forel scale in the towns of Nova Scotia, more than 400 miles from its origin, and it occasioned a tsunami or earthquake wave, which drowned twenty-six persons on the Burin Peninsula in Newfoundland, did extensive damage to property and in places swept inland to the height of one hundred feet.

A map, based on one kindly supplied by L. Robinson of the Western Union Telegraph Company, and on a list of seven breaks on the cables of the Commercial Cable Company by R. J. Hughes, shows that the breaks are mainly in two roughly parallel lines in continuation of the trough-like valley, in places 285 fathoms deep, through Cabot Strait. The lines are not fully straight; but as the positions of the fractures are based on tests from the shore ends they may not be exact, as they may be displaced by strains or injuries to the cable outside the main fractures.

Eleven of the twelve damaged cables have two fractures apiece, at the distance of usually from eighty miles to 150 miles apart. The positions are roughly in two lines, which continue the straight, steep side of the trough of Cabot Strait. That trough is up to 285 fathoms deep and trends from northwest to southeast. The earthquake appears to have been due to a renewed subsidence on the submarine southern continuation of Cabot Strait, though the trend bends to south-southeast. The depths along the middle of this sunken bend were 1,750, 2,332, 2,680, 3,450 and 2,934 fathoms, and the depth is usually hundreds of fathoms greater than in the area on either side. The earthquake is probably due to a fresh subsidence of the floor of this submarine rift valley.

The new evidence throws light on the nature of the famous submarine canyon of the Hudson River off New York, which makes a notch in the 100-fathom line by a depression 2,400 feet deep. The buried channel inland is known to be in places bounded by faults.

The St. Lawrence Valley has been interpreted by Mgr. Leflamme as a strip sunk between parallel faults. Its tributary, the Saguenay fiord, the site of the powerful earthquake of Feb., 1925, the latest of the violent shocks of the Charleston-New England-St. Lawrence series, is probably due to subsidence, as its bed is in places 140 fathoms below sea level. It trends approximately east and west in line with the pivotal line across Newfoundland.

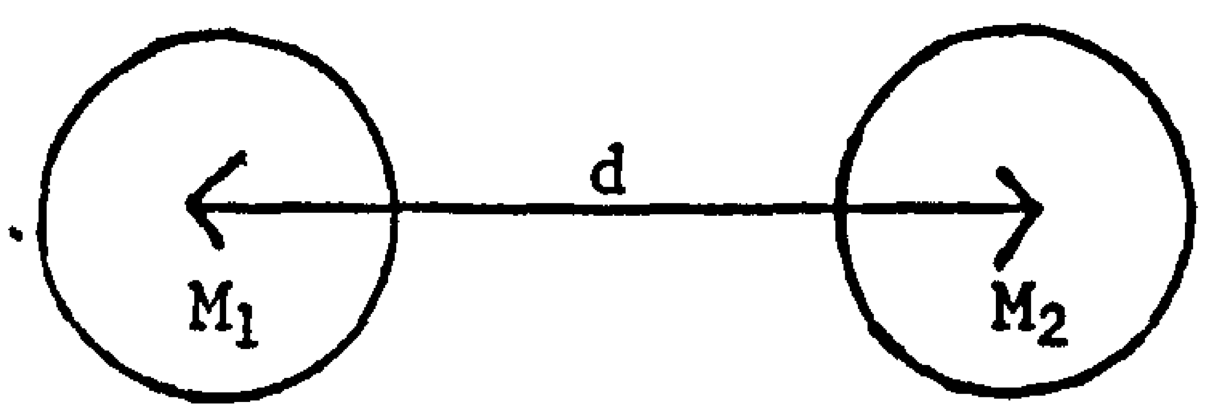
Such submarine canyons have been attributed to four processes: to excavation by rivers when the land stood thousands of feet higher than at present; to the power of glaciers to excavate troughs deep below sea level; to the accumulation of sheets of sediment on either side of a channel kept clear by currents, as suggested by Darwin for the canyons of the Blue Mountains in New South Wales, and by J. Y. Buchanan for the Submarine canyon off the Congo. The fourth explanation is that they like fiords, are due to the subsidence of strips of land along faults; that conclusion, advanced in "The Nature and Origin of Fiords," appears strongly supported by the evidence of this new earthquake, which in this case has not enjoyed the comparative harmlessness of submarine disturbances, as it lies across the main series of transatlantic cables.

The resounding of the ocean bed around the epicentral area of the Cabot Channel earthquake may reveal instructive changes in depth.

Tides

Waves are one type of rhythm that we can observe in the sea. Sometimes they are large and violent, while other times small and gentle, always the sea is in motion. Tides, unlike waves, have a more predictable rhythm, coming and going every day. Man has always been fascinated by the tides, and has used them as an energy source for several hundred years.

Our understanding of the mechanism of the tides is based on the work of Isaac Newton (1642-1727). Newton proposed the theory of gravitation, and used his theory to account for the tides. Newton's theory of how tides are formed is known as the EQUILIBRIUM THEORY. Newton suggested in his theory of gravitation that all objects attracted each other with a force which depended on the mass of the objects, and the distance between them.



Thus if we consider two objects of masses M_1 and M_2 a distance d apart, the force of attraction between them is F.

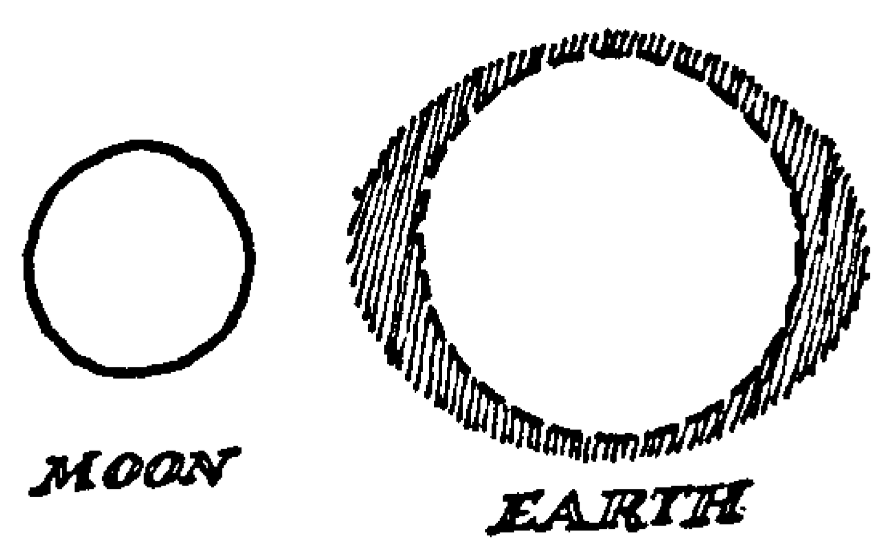
$$F = \frac{G \; M_1 \; M_2}{d^2}$$

G = Universal gravitational constant.

The important thing to note about this formula is that:

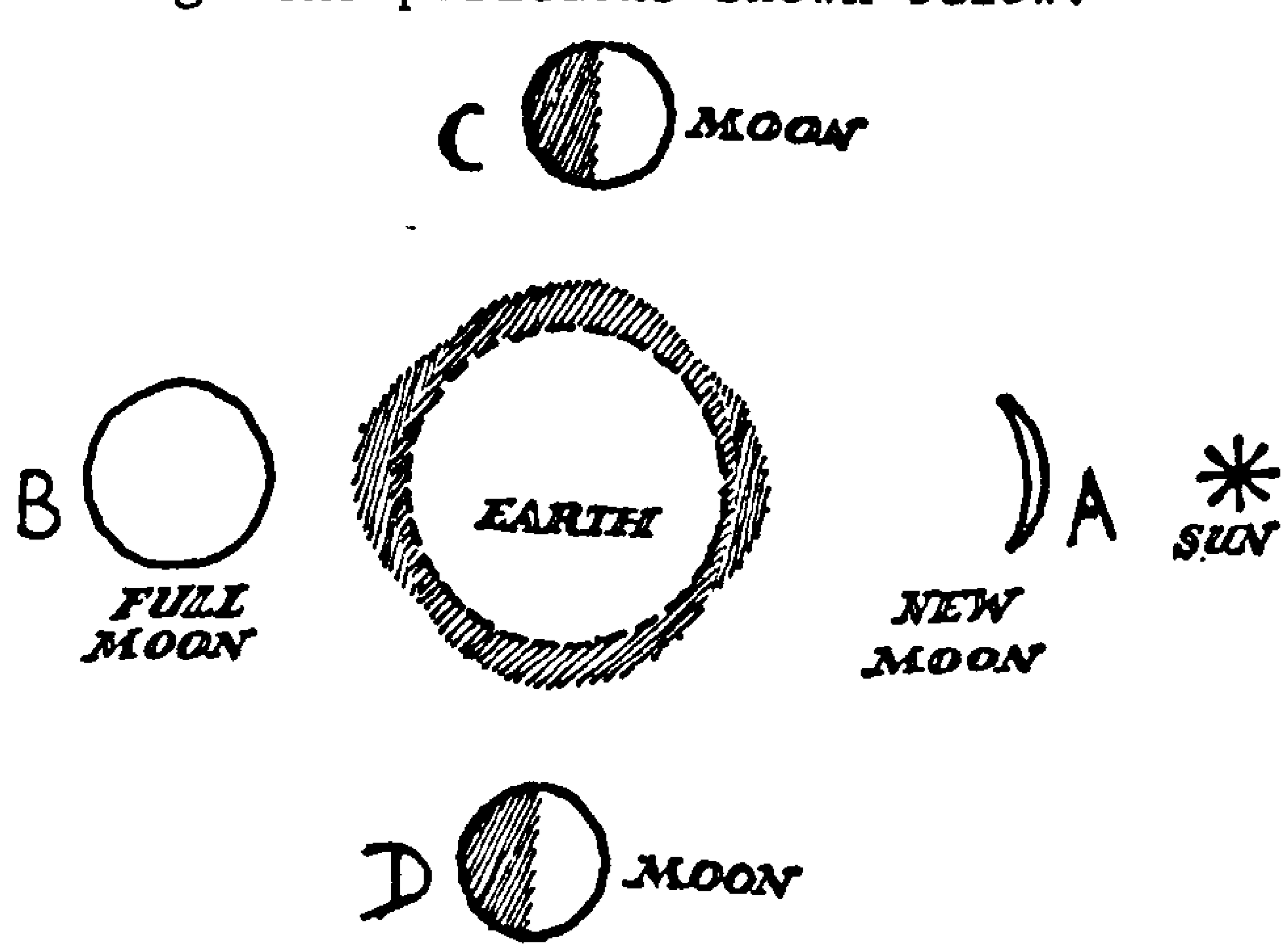
1. The greater the mass of the objects the larger the force of attraction between them.
2. The greater the distance apart the objects are, the smaller the force of attraction between them.

Now Newton's theory of gravitation applies to all objects. Thus for example, there is a force of attraction between two students sat near to each other, however, since our masses are comparitively small this force is so tiny it is not noticed. However astronomical objects such as the Sun and Moon have such large masses that their gravitational forces have a considerable effect on our world. In producing a simple explanation of the tides, Newton imagined that the Earth was totally covered with water. He then showed that the pull of gravity of the Moon combined with the effect of the Earth and Moon orbiting around each other produced two bulges of water.



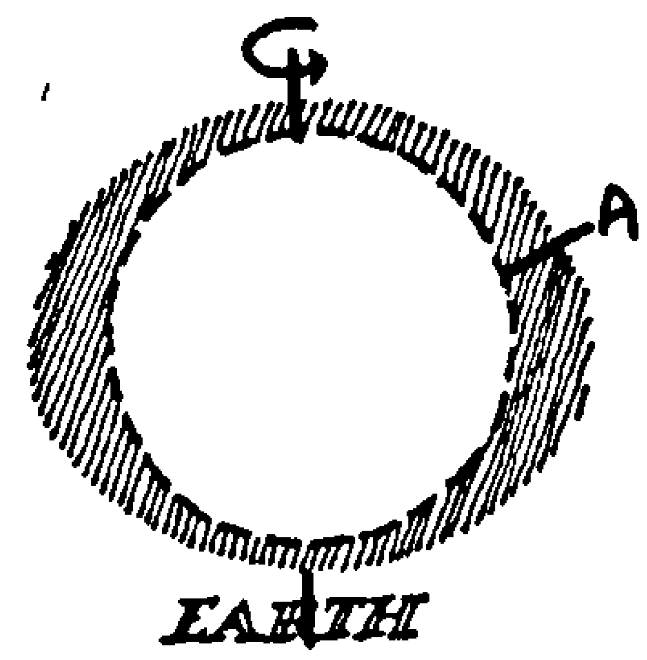
You will note these bulges are on opposite sides from each other. The Sun also produces a similar effect although the bulges produced by the Sun are less than that produced by the Moon. Why do you think that is?

Now in the course of a lunar Month (28) days the Moon, Earth and Sun move through the positions shown below.

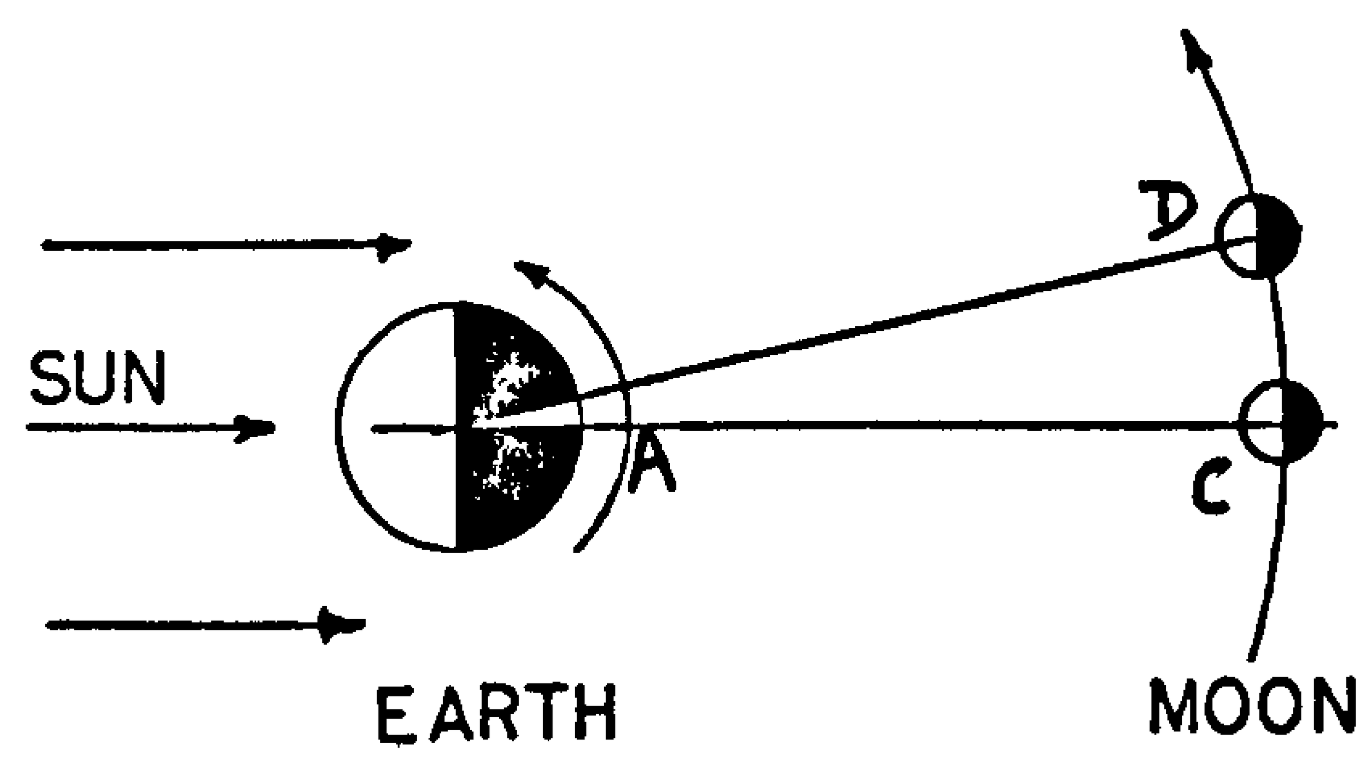


At A and B the tidal bulges caused by the Sun and Moon Act in the same direction, while at C and D they act at 90° to each other. Thus at A and B the tidal bulges are at a maximum, while at C and D they are at a minimum.

Now let us consider the effect of the Earth's rotation. It is easiest to think of the Earth as rotating within the covering of water. During the course of one rotation, a point A on the Earth's surface passes through both of the bulges.

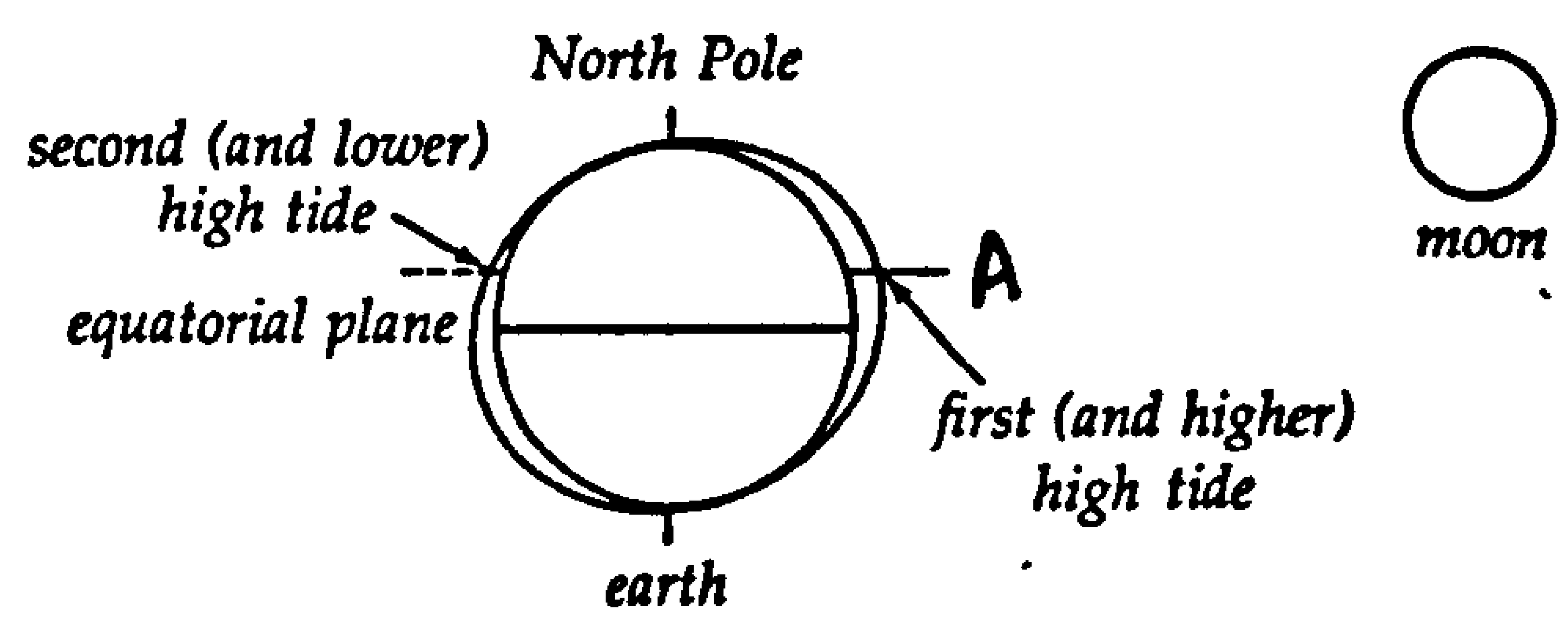


However, while the Earth rotates once, the Moon also moves in its orbit. In the diagram below while point A rotates around once, the Moon moves from C to D. Thus it takes a little longer for A to get to the same position relative to the Moon. Thus the lunar day is 24 hr 50 minutes.



Thus during a lunar day a point on the Earth's surface will experience two high tides (when it is under a bulge) and two low tides - Thus the difference between successive high tides should be 12 hours 25 minutes. These daily tides are also influenced by the relative positions of the Sun, Moon and Earth. Since the tidal bulges are larger at Full Moon and New Moon, it follows the tides will be higher at these times. These tides are called SPRING TIDES. When the tidal bulges have a minimum value (see previous diagrams) the tides are called NEAP TIDES.

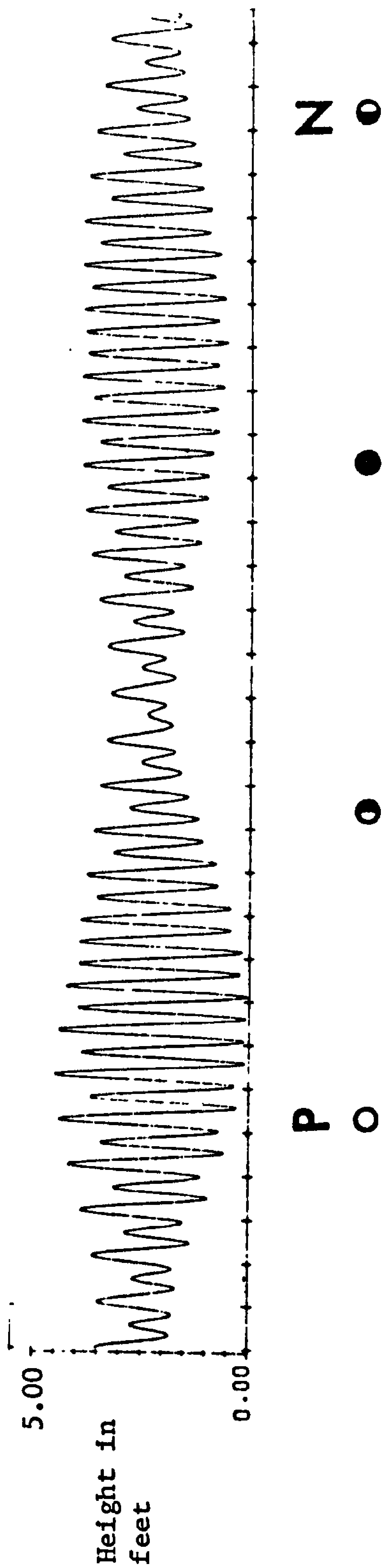
One other point to mention in this very simple account of the tides is that the Moon does not rotate in the same plane as the Earth's equator. This means that the tidal bulges do not lie on the equator, thus as a point A rotates it will pass through waters of different depths, since it passes through different parts of the two bulges.



Thus although any point on Earth will experience two high tides and two low tides their heights will not be equal.

Assignment:-

Examine the diagram. It is the record from a tidal gauge in St. John's harbour, and a small section from a tide-table. Answer the following questions. In each case do your observations agree with the simple account of the tides given above.



Day	Time	Ht./ft.
12	0010	3.9
	0620	1.8
FR	1220	3.6
VE	1830	1.7
13	0110	3.9
	0740	2.0
SA	1330	3.3
SA	1930	1.8
14	0225	3.9
	0920	2.0
SU	1500	3.2
DI	2050	1.9
15	0355	4.1
	1050	1.8
MO	1630	3.3
LU	2210	1.9
16	0510	4.4
	1155	1.5
TU	1740	3.5
MA	2320	1.7
17	0615	4.7
	1250	1.2
WE	1840	3.7
ME		
18	0025	1.6
	0705	5.0
TH	1335	1.0
JE	1925	4.0
19	0115	1.4
	0750	5.2
FR	1415	1.0
VE	2010	4.2
20	0205	1.3
	0830	5.3
SA	1455	1.0
SA	2055	4.3
21	0245	1.3
	0910	5.2
SU	1530	1.1
DI	2130	4.3
22	0330	1.3
	0945	4.9
MO	1610	1.3
LU	2210	4.3
23	0405	1.5
	1020	4.6
TU	1640	1.5
MA	2245	4.2
24	0440	1.7
	1055	4.2
WE	1710	1.7
ME	2320	4.1
25	0515	1.9
	1125	3.8
TH	1745	1.9
JE	2355	4.0
26	0600	2.2
	1200	3.4
FR	1820	2.1
VE		
27	0045	3.8
	0700	2.4
SA	1235	3.1
SA	1905	2.2
28	0145	3.7
	0845	2.6
SU	1430	2.9
DI	2015	2.3
29	0305	3.7
	1105	2.4
MO	1630	2.9
LU	2140	2.3
30	0435	3.8
	1205	2.1
TU	1740	3.0
MA	2255	2.1

a. How many high tides are there in a 24 hour period?

b. Are the high tides the same height in a 24 hour period?

c. What is the time difference between successive high tides?

d. Do the high tides appear to vary during the course of the month?

Further Thoughts on the Tides --- and Science

Examine the tide record shown earlier, point A is the time of full moon for that month. Does it correspond with a spring tide? Do your observations correspond with Newton's account of tides?

A closer examination of the behaviour of the tides reveals many other departures from the simple pattern suggested by Newton's theory. Thus some parts of the world have only one tide per day, while others are almost tideless. Often wide differences occur within small distances of each other. Thus at the Caribbean end of the Panama Canal there is one tide per day, while at the Pacific end there are two per day. It should not really surprise us that Newton's theory is not perfect, he did not attempt to take into account the shape of the ocean basins, or the effect of large masses of water moving and many other factors. So Newton's theory does not really work in accounting for tidal behaviour, however, it does contain a thread of truth.

In science this situation is met many times, a theory may not be totally correct, it may give only a partial explanation. However, that does not mean that the theory is then discarded since it is rarely that a theory is totally wrong. Thus usually the theory is revised and extended. This may sound a messy way of carrying on, yet this step by step procedure is the way science progresses. So Newton's theory was not discarded but has since been modified by more complicated mathematical theories which consider the tides as huge waves.

V. LIFE IN THE SEA

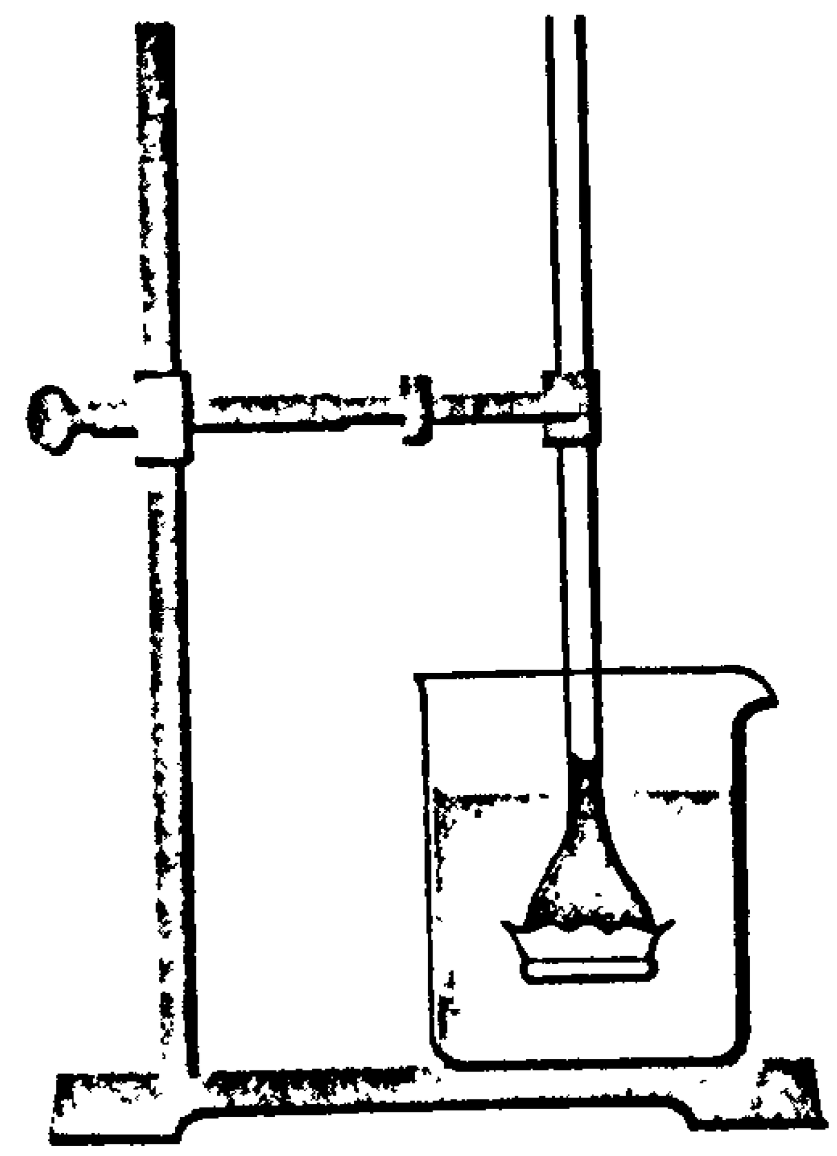
Living in an island province we are probably more aware than most people of the enormous variety of life in the sea. Economically Newfoundland has depended on the sea since the island was first settled. Although the fishery has declined in recent years, life in the sea and around the coast of Newfoundland is still plentiful. In this unit we will consider some general principles governing life in the sea, as well as looking at some of the organisms that are common to the seashore around the Province.

Life in Seawater

You found, in an earlier section, that because of the ability of water to dissolve substances, seawater is a mixture containing many different substances. The concentration of minerals in seawater produces certain difficulties for organisms which live in the sea. The following three activities will help us to understand these difficulties.

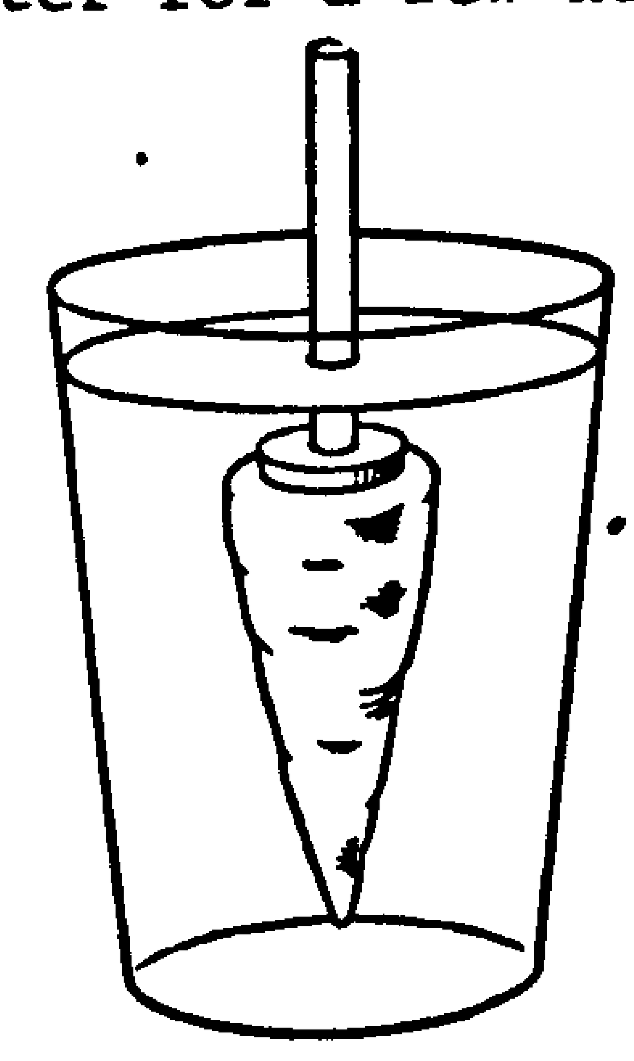
Take two eggs, and allow them to stand in dilute hydrochloric acid or strong vinegar. Leave them until the shell has dissolved and only the membrane remains. Remove the two eggs from the liquid and rinse gently, handle with care at this point since the membranes are easily broken. Place one egg in a beaker of fresh water and the other in a saturated salt solution. Leave for 20 or 30 minutes, remove the eggs from the liquid and examine carefully. Record any changes you have observed.

Set up the apparatus below, if the glass funnel is not available your teacher will tell you how to make a substitute. Tie the membrane around the end of the funnel tightly using several turns of strong thread.

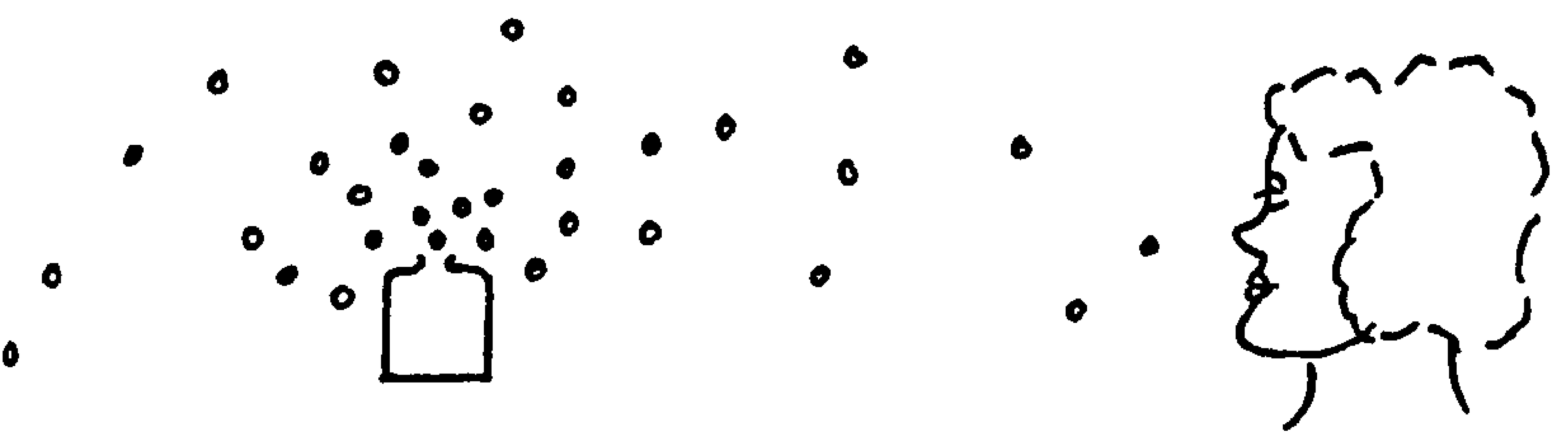


Into the funnel pour a very strong salt solution, or sugar solution, or a mixture of molasses and water. Note the initial level of the liquid in the tube. Allow the apparatus to stand for several hours. Record your observations.

Find a large carrot, or small parsnip and scoop a hole in the top of it about an inch deep. Fill the hole with a concentrated sugar solution. Insert a tightly fitting cork or bung which has a length of glass tubing in it. Seal around the bung with candle wax. Place the carrot in a glass of water for a few hours. Record you observations below.



The observations you made in the above activities are examples of DIFFUSION, which is the movement of materials from a region where it is highly concentrated to a region where it has a low concentration. Think for a minute of a bottle of perfume when it has the top removed. Around the top of the bottle there are many perfume molecules in the air, while around your nose there are none. Very quickly the perfume molecules spread out from the bottle from high concentration to low, and you soon smell the perfume.



HIGH CONCENTRATION LOW CONCENTRATION

Now consider the egg in the first activity. An egg can be regarded as a mixture of water and other substances. The membrane you left surrounding the egg is what is called a SEMI-PERMEABLE membrane, this means it will allow some substances to pass through it e.g. water, but not others. When your egg was placed in fresh water, the concentration of water was greater on the outside than inside. Thus water passed into the egg. Did your observations agree with this?

Explain what happened to the egg which was placed in the strong salt solution? Explain why. (Note that there is a lower concentration of water outside the egg than inside.)

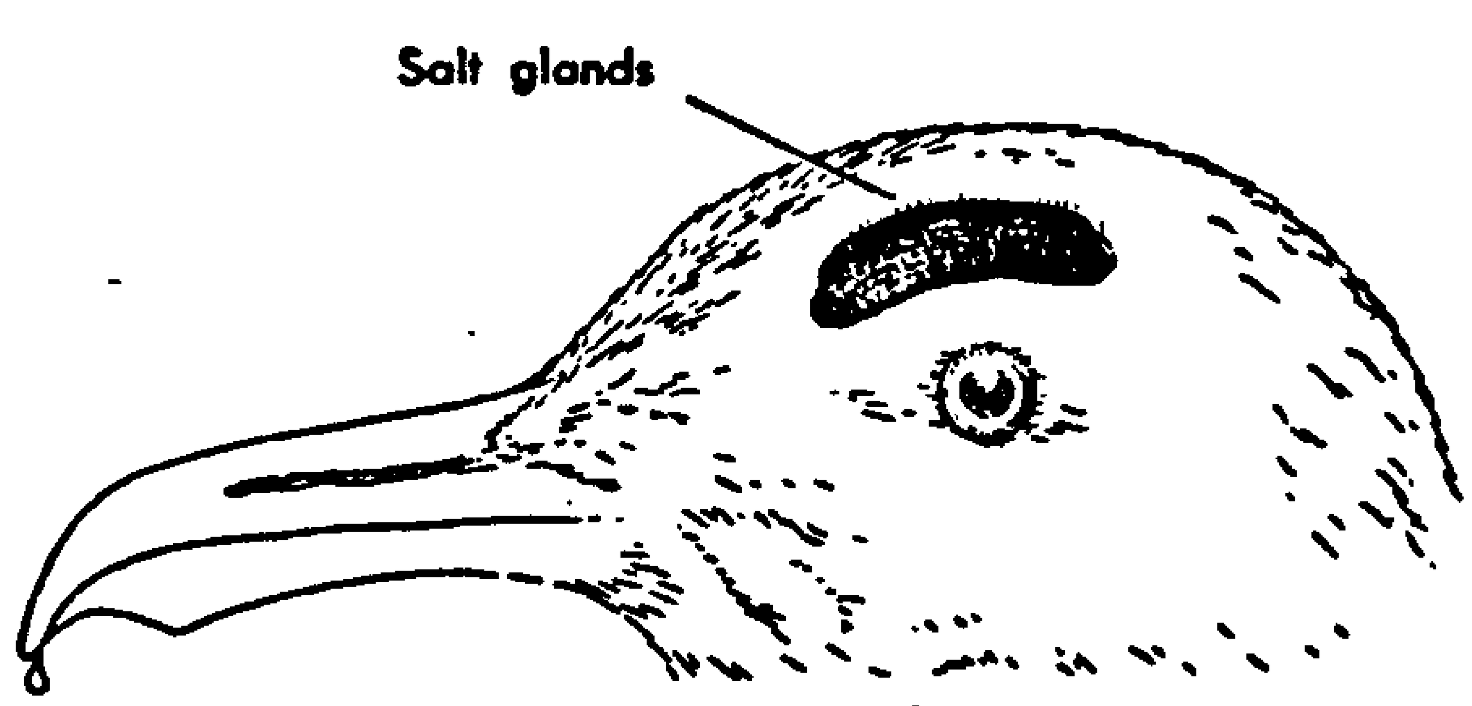
Explain what happens in the other two activities.

The movement of water through a SEMI-PERMEABLE membrane from a high concentration to low concentration by the process of diffusion is called OSMOSIS.

Now let us return to organisms which live in the sea. Most of the marine plants and invertebrates that live in seawater have approximately the same concentration of water in the cells as is in the sea. These organisms will neither gain or lose water by osmosis.

However the cells of a bony fish have a higher concentration of water than seawater. What would you expect to happen to the fish?

Fish have to use energy to combat this process. They drink in seawater and then desalt it. The freshwater is then distributed to the cells of the fish, while the salt is returned to the ocean at the gills. Sea birds and turtles use a similar method to take freshwater from the sea. The herring gull has salt glands in the head which desalt seawater, enabling it to absorb freshwater. The salt is expelled to the outside as a very concentrated solution through the nostrils.



Assignment:-

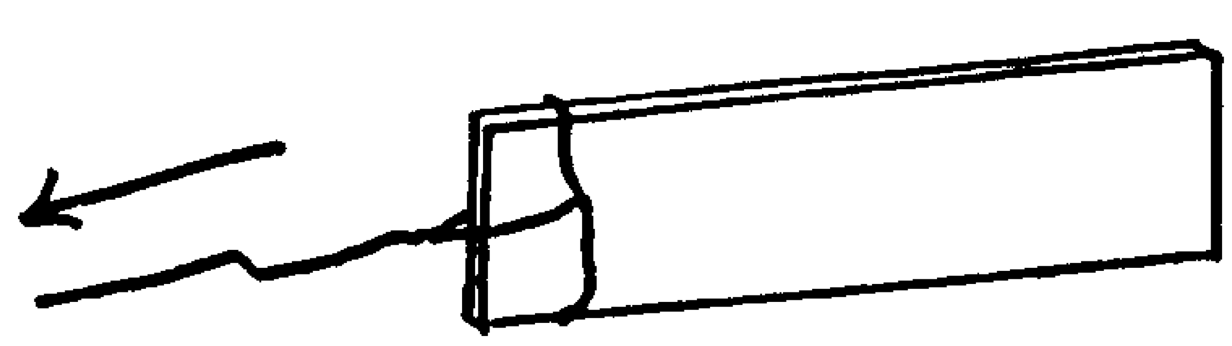
Fill two beakers, one with seawater, and one with freshwater. Into both put a piece of seaweed and a piece of pondweed? (Make sure both weeds are fresh). Observe what happens to both after a few hours. Explain why?

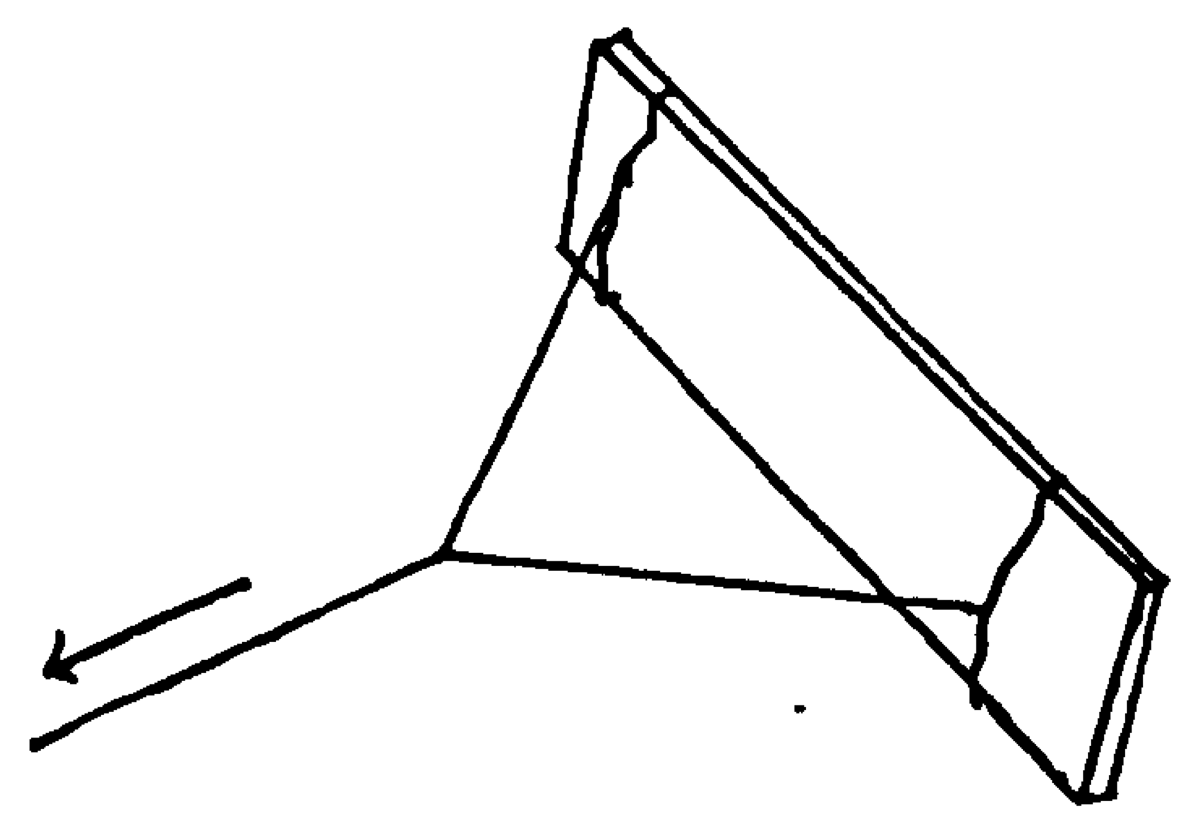
Movement in the Sea

In a previous section we saw that the low viscosity of water enabled objects to move through it comparitively easily. Animals that live in water have shapes that allow them to move through the water with comparitive ease.

If you can go to a swimming pool, you can carry out some simple observations on the effect of shape on the movement of a body through water.

Try swimming towing a plant of wood about 18" long attached to one end. Compare it to the effort required to pull the plank tied so that it moves face forward.





Compare the effects of towing a friend along when he is stretched out or is "hunched" up in a kneeling position. Which is easiest?

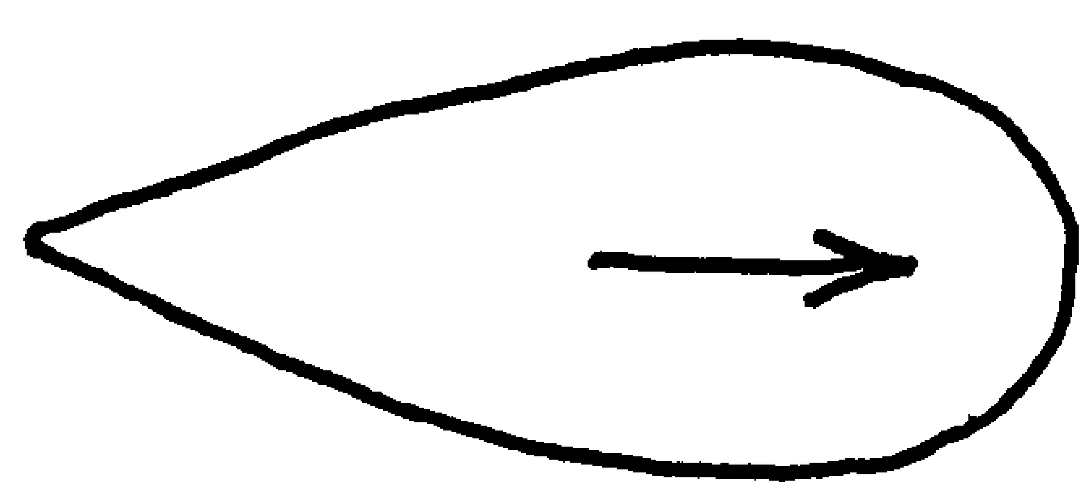
Try running across the shallow end of the pond. Why do you think it is difficult to run?

Again compare the effects of towing a friend along, when he is in a stretched out position with his legs together and then with his legs apart. Which is easiest?

The activities you carried out in the pool should have given you some ideas about what sort of shape is best for moving through water.

Let us try to determine more carefully which shape is best suited to move through water. You will compare different shapes falling down through a column of liquid. Use small pieces of plasticine as the objects, they can easily be modelled into the required shapes. Use a lead shot in each piece to make it fall the way you require it. Now before you go ahead think of any variables that you wish to control in the experiment, and how you will measure the speed at which the object falls. Write below a brief account of how you carried out your experiment, record your results and any conclusions you come to.

The most efficient shape at moving through a liquid is a torpedo shape, not only is it rounded at the front, but tapered at the back. This tapering reduces the drag of the liquid, and the object can move smoothly through the water.

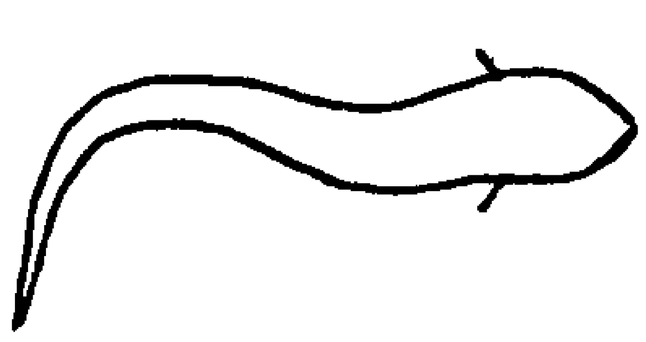


Assignment:-

1. Consult some reference material and sketch the body shapes of as many different species of whales, as you can. Are their shapes streamlined?

2. Consult some magazines and papers for pictures of cars and planes. Sketch any that you think show the torpedo shape as a basis of its design.

So far we have considered the shape best suited to movement through the water. Now we will briefly consider how fish swim through water. If you have seen a fish swimming in a stream you will notice it moves from side to side in an S motion.



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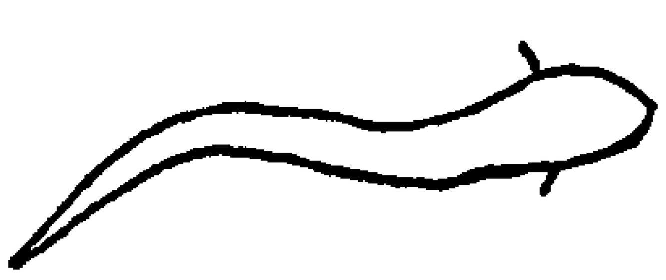

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6

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8

9

Put your hand in water and move it to and fro in the same sort of S shaped pattern. You can feel the force generated on the water, and the tendency for your hand to move.

In the following activity you will examine a fish and see the muscles which produce this motion.

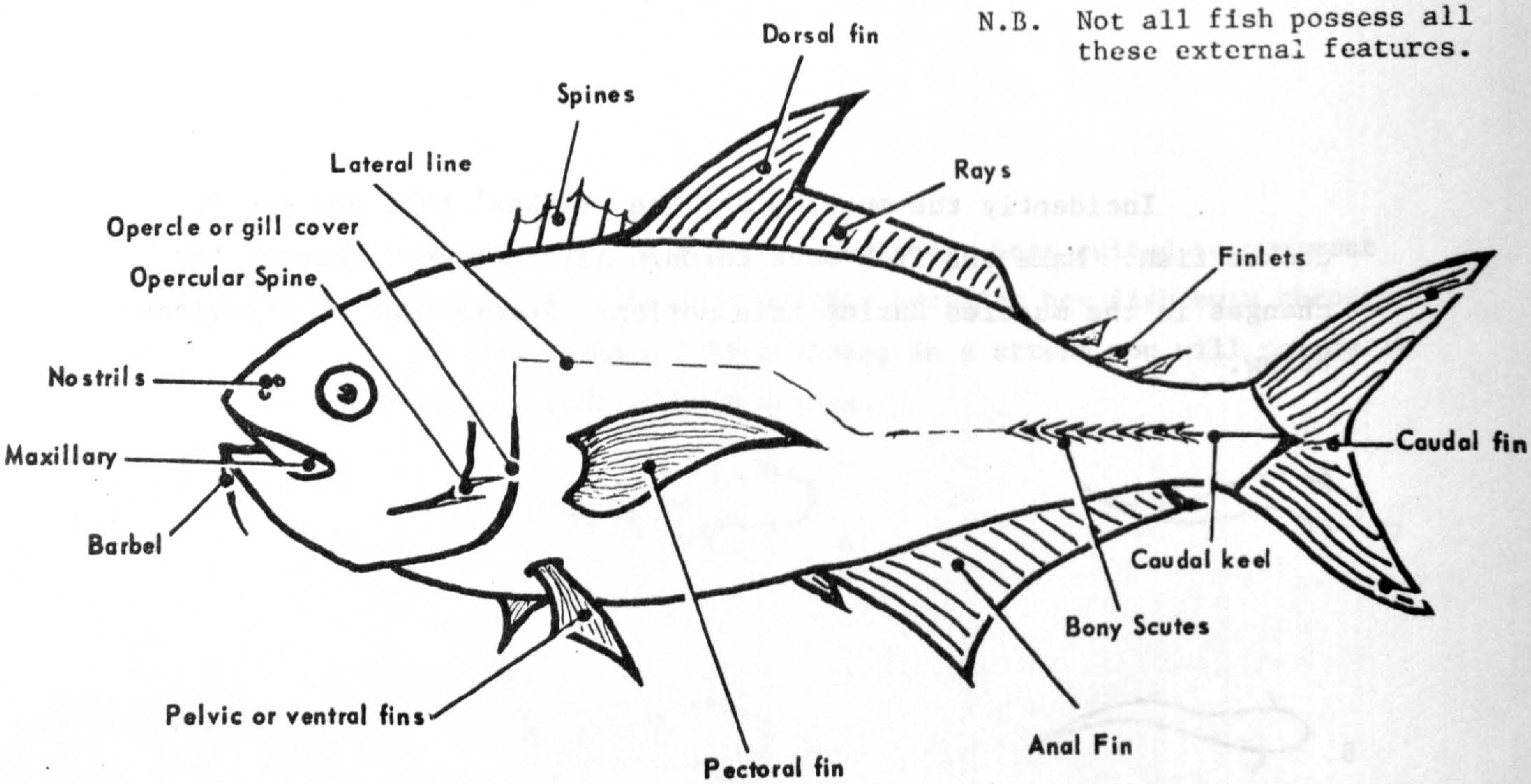
Spread the fish out on a paper towel, and using a sharp razor blade remove the skin from one side of the fish. Cut away the surface tissue to reveal muscles underneath. Sketch your observations below.

Incidently the muscles are the 'flakes' that you see in cooked fish. Make the fish move through an S motion. Observe the changes in the muscles during this motion. Record your observations below.

Cut the fish in half and observe how the muscles are attached to the backbone. Sketch the arrangement below.

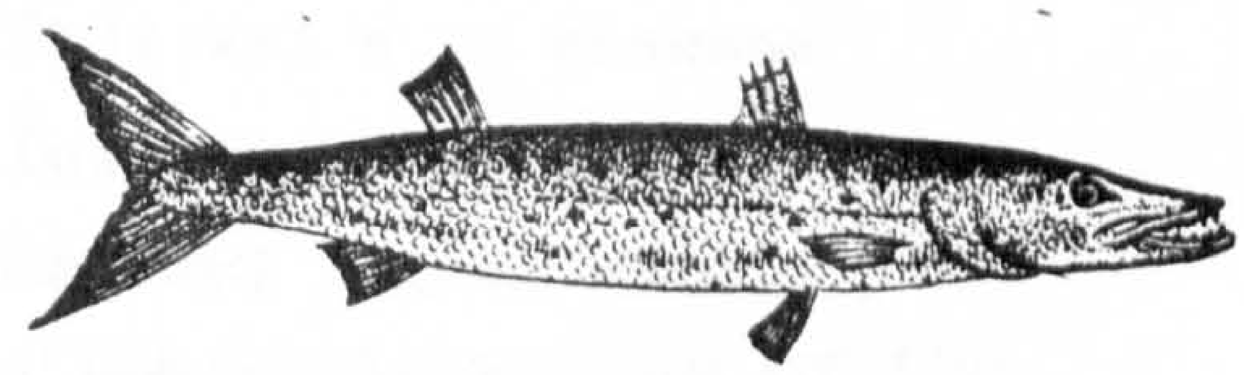
Below is a labelled diagram of a fish. The fins are generally not used to provide power for swimming, rather they act as stabilizers. The Dorsal and Anal fins help to prevent rolling from side to side, similar to a keel on a boat. The Pectoral and Ventral fins help to prevent pitch, similar to stabilizers fitted to ocean liners. Although a fish swims with a side to side motion of its tail, it should be noted that whales move their tales up and down.

N.B. Not all fish possess all these external features.

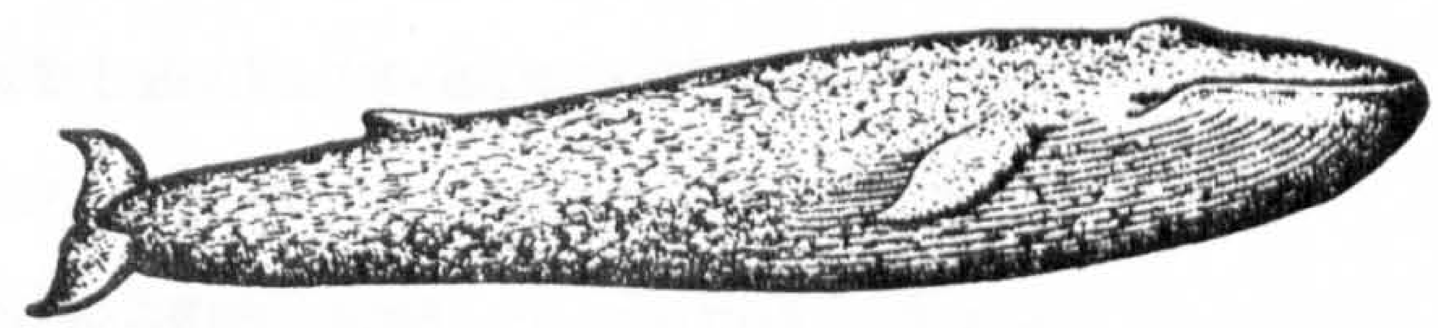


Scientists are particularly interested in the speeds at which fish can swim. If you disturb a trout in a stream it seems to swim away at a very high speed, however, the speeds of fish are less than most people imagine. Below are the maximum recorded speeds of certain aquatic creatures.

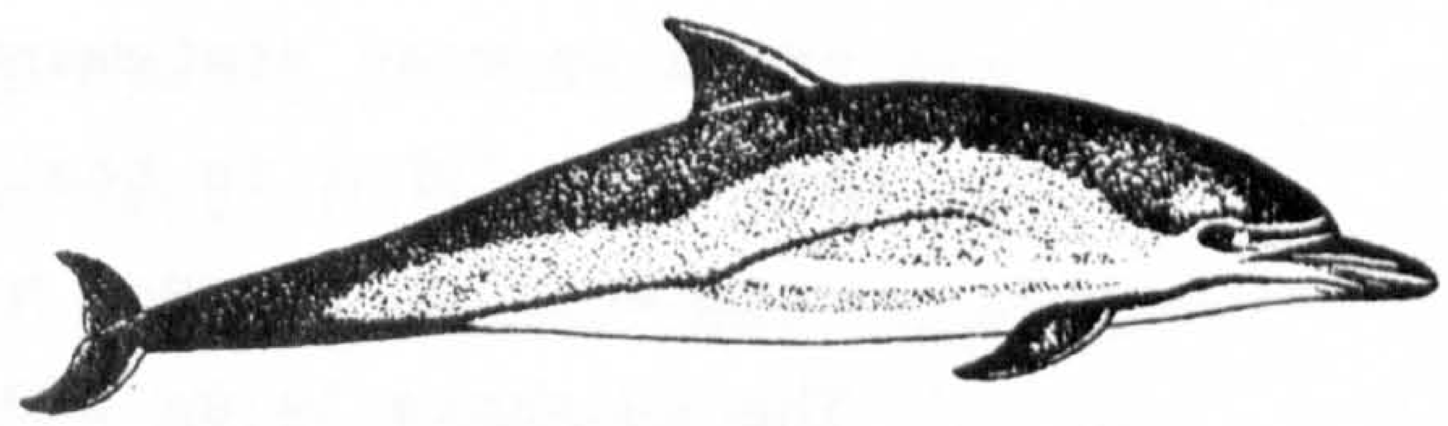
BARRACUDA 43 km.p.h.



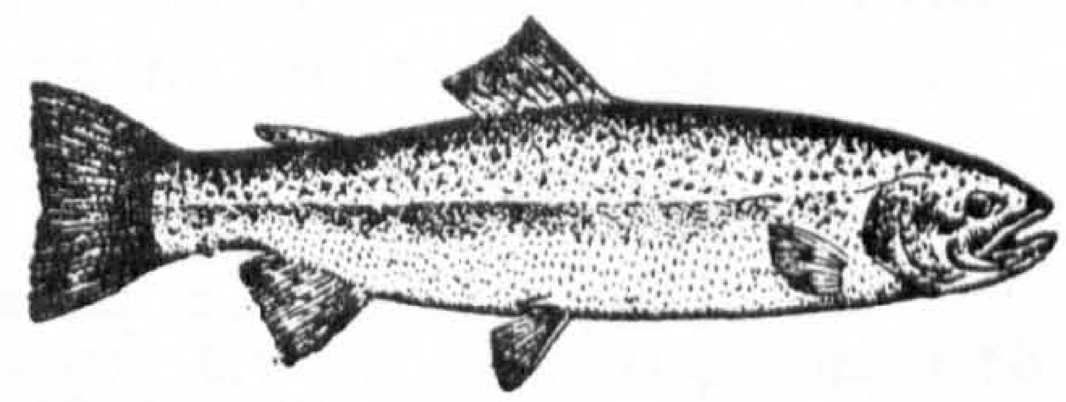
WHALE 32 km.p.h.



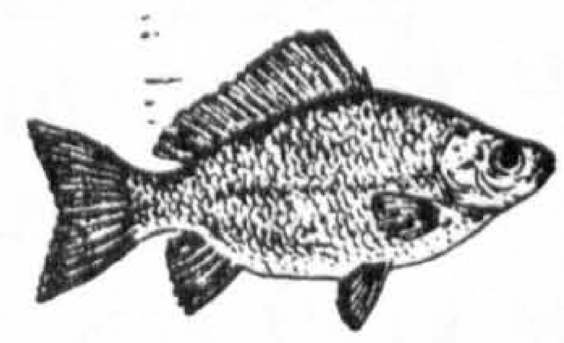
DOLPHIN 37 km.p.h.



TROUT 16 km.p.h.



GOLDFISH 16 km.p.h.



Project:-

Your teacher will provide you with the plans to make a mechanical fish.

Life by the Shore

Most people, at one time or another, have taken a walk along the shore, and will have seen some of the life that exists there. Too often we make only casual observations, and notice a few strands of seaweed or a few shells. However if you spend a little time at low tide and make careful observations, an abundance of living material can be seen. Even more careful observation and research reveal that there exists, among all these organisms, patterns and order. In this unit we will look at some of the more easily found organisms which inhabit the seashore around Newfoundland.

One word which is used very commonly today is ECOLOGY. How often we read statements in the newspaper about "protecting the ecology ----" or "what is best for the ecology is ----". In most cases the word ecology is used wrongly, in fact it means the study of ECOSYSTEMS. The seashore is an ECOSYSTEM, and by this we mean it can be regarded as a unit in which the various organisms which live in it, are interelated to one another and to the physical surroundings in which they live. In this unit we will not be concerned with the study of the seashore as an ecosystem, however we will try to see how the physical conditions on the seashore affect the organisms which inhabit it. We will also examine how the organisms of the seashore are dependent on each other.

Field Trips

It is hoped that you will be able to visit a seashore during your science class, and collect specimens for the activities during this unit. If you do go on a field trip your teacher will discuss with you the procedures and precautions to be followed. However, one point which should be mentioned here is that the purpose of a field trip is for observation and deduction, not to collect as much living material as you can. If every member of a class of students were to remove a large amount of material, then a lot of damage could be done to the ecosystem. So on your visit to the seashore, collect only what you need. If you pick up an organism to examine it, and do not wish to collect it, return it carefully to where it was before.

Seaweeds

One of the most obvious forms of life that we find by the seashore are seaweeds. Seaweeds are an important part of the ecosystem, they are PRODUCERS, by this we mean they are able to trap the energy of the Sun and convert it to food. The process by which they do this is PHOTOSYNTHESIS, and we will look at this process in more detail in a later module. Although seaweeds are not the only producers we can find in the sea, the fact that they can convert the sun's energy to food, and also serve as food sources for other organisms that inhabit the sea shore, makes them an important part of the seashore ecosystem.

Seaweeds are known as MARINE ALGAE by scientists. They are classified into different groups on the basis of their colour, and other observable properties. Before you attempt to identify any seaweeds that you find, it is important that we consider what we mean by the term CLASSIFICATION. If we wish to find out something about the properties of some objects such as plants, then providing there are only a few of them then there is no great difficulty. However imagine we are trying to find out something about the properties of several thousand objects, then we can imagine some of the difficulties we might encounter. How do we name them? Must we do all our tests and experiments on every single object. How do we record our findings? Generally when faced with such a problem we attempt to group the objects according to properties they have in common. Thus, for example, you may wish to group the students in a class into, boys and girls, blue eyes or brown eyes, etc. This process of grouping objects according to their properties is what we term CLASSIFYING.

The classification system used by biologists is complex but is universally accepted. Why is this important?

Note that classifying is not simply a process used by Scientists. Explain why the term "Classified Advertisements" is used by Newspapers?

When naming an organism, it is given two names. In fact more names are used in classifying it fully, however two names are usually sufficient. The first name is its GENUS, the large group to which it belongs. The second name is its SPECIES name. Thus humans are:

HOMO (genus) SAPIENS (species)

and the domestic cat:

FELIS DOMESTICA

and the dolphin

DELPHINUS DELPHIS

Now we do not usually refer to the domestic cat as FELIS DOMESTICA, because its common name, CAT, is well known. However seaweeds usually do not have common names that are well known, so they are referred to by their scientific names.

As you collect the seaweed, you may observe that there appears to be three basic colours, RED, BROWN, and GREEN.. These colours are one of the properties on which seaweeds are classified. However, other properties besides colour are used to classify seaweeds and in order to identify them we need a CLASSIFICATION KEY, which enables you to decide what your specimen is by making certain observations. Your teacher has several copies of "Common Seaweeds of Newfoundland" by Dr. G. R. South of Memorial University. This book contains a simple key which if you follow it carefully will enable you to identify specimens.

Collect specimens of different seaweeds you can find, and keep them in a container of seawater so they can be returned in a fresh condition to the school laboratory. The following directions should be followed.

a. Choose only fresh specimens, not broken or decayed.
b. Label and record where you found them on the shore.
c. Collect and record any living materials you find on them.

On the following pages make a sketch of a small section of each specimen, and record where you found them, and if possible the name. Note as well any life that appeared to be present on them. Make a mount of one of your best specimens. "Common Seaweeds of Newfoundland" contains simple instructions on how to make an attractive mount.

Survival on the Seashore

If we stop and think for a minute about the conditions that exist on the seashore, it is amazing that we find any life at all. The organisms are regularly covered and uncovered by the sea. They must be able to survive when exposed to wind and sun. They must be able to withstand the battering of waves and storms. They must be able to obtain their food when required. Even a little imagination makes it apparent that the seashore is a difficult place for organisms to survive. The organisms that live by the seashore have many physical characteristics which help them survive on the seashore. The characteristics are called ADAPTATIONS.

One of the seaweeds that you will almost certainly find is the FUCUS, there are three fairly common species, and you should be able to obtain some specimens in good condition. Examine one carefully and try to answer the following.

a. How does it remain in place on the seashore?

b. What advantage does its leathery texture give?

c. What does it appear to be covered with? Why?

d. What are the air bladders for? Remember the work you did on floatation, and the fact that the plant needs light to make food.

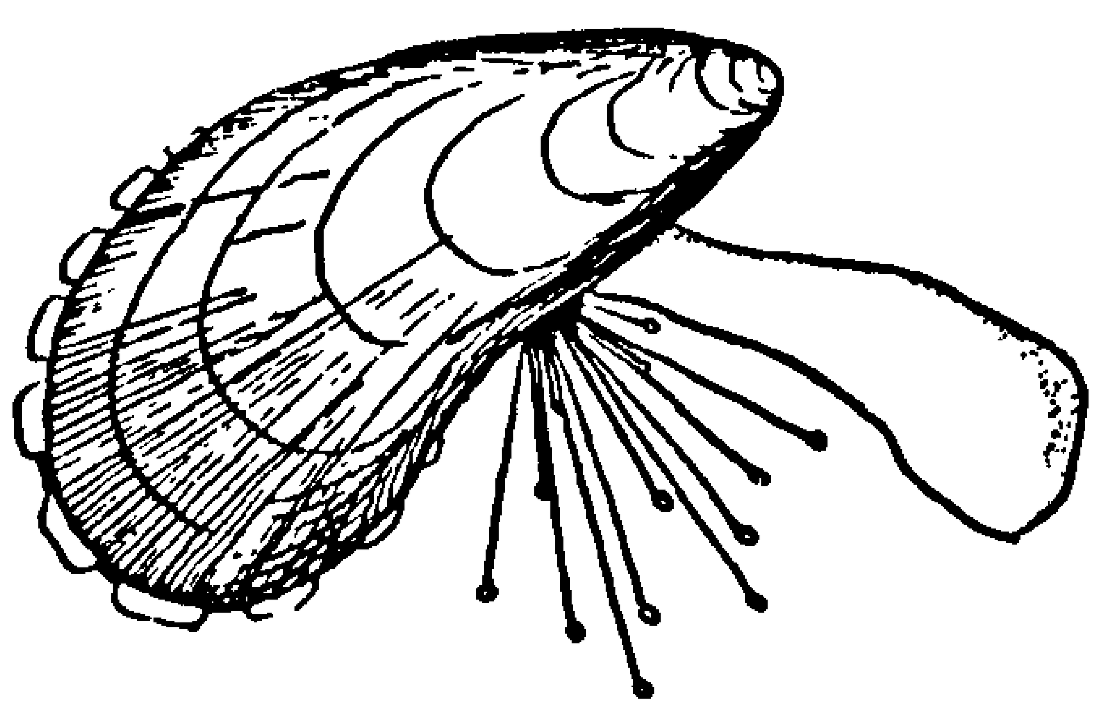
In this next activity you are going to investigate how the seaweed is able to survive exposure to the atmosphere at low tide. You are going to first record its loss of weight as it dries, and then investigate how quickly it absorbs water again. Take a fairly large piece of seaweed and drain the water off and attach it to a spring balance and suspend it in a current of air. Record the weight every half-hour for five hours. To see how quickly the plant reabsorbs water, you will dip it in seawater, allow it to drain and weigh. Repeat this at ten minute intervals. Note it is important to standardize your technique for this second part, your teacher will discuss this point with you.

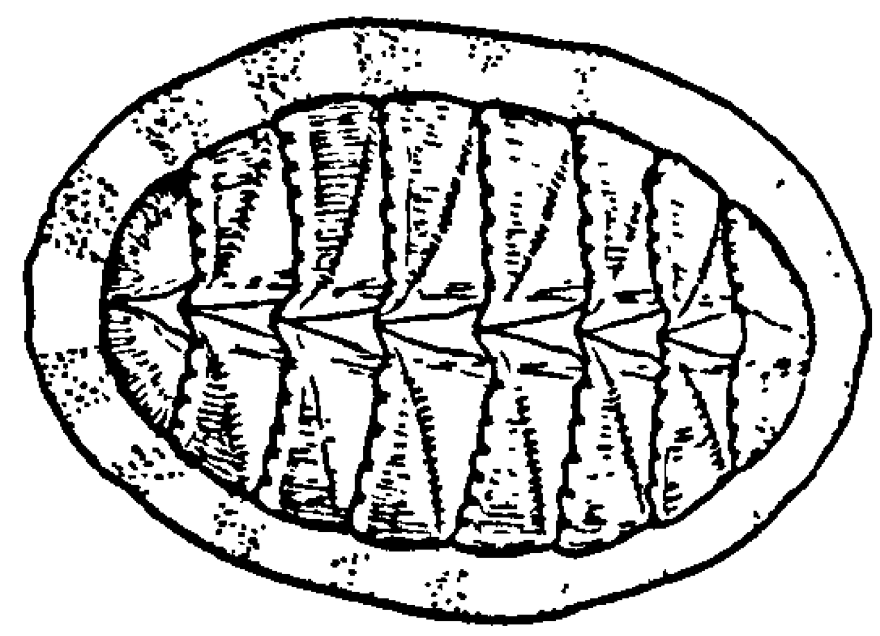
Record your results below, and plot a graph of the weight of the seaweed against time. What do your results indicate about the ability of the plant to survive on the seashore?

Other Inhabitants of the Sea Shore

Careful observation will reveal a large number of other inhabitants of the rocky shore. Your teacher will have some pictures of the more common ones you might be able to find. Below are drawings of some of them that will also help in identification.

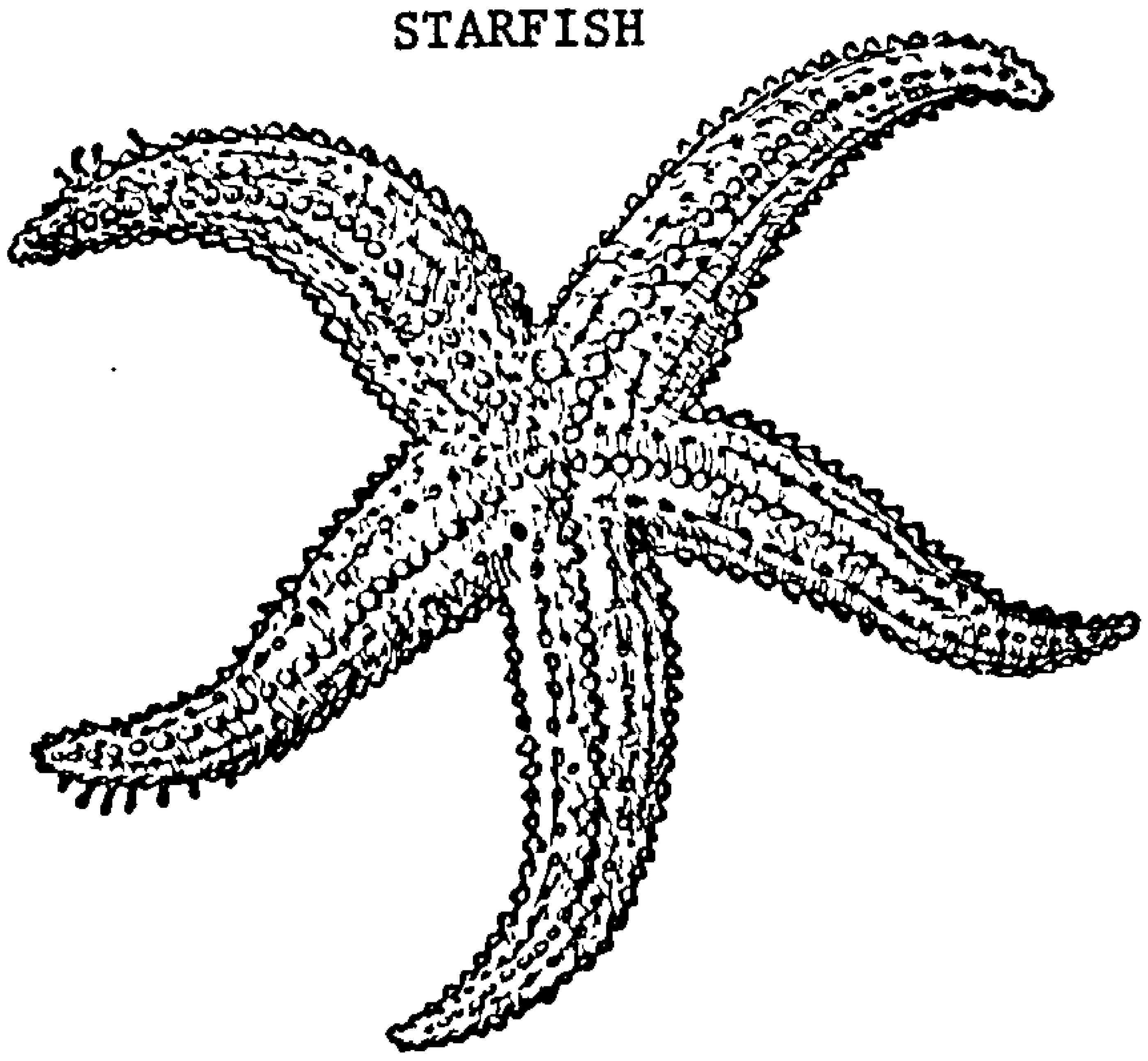
MUSSEL

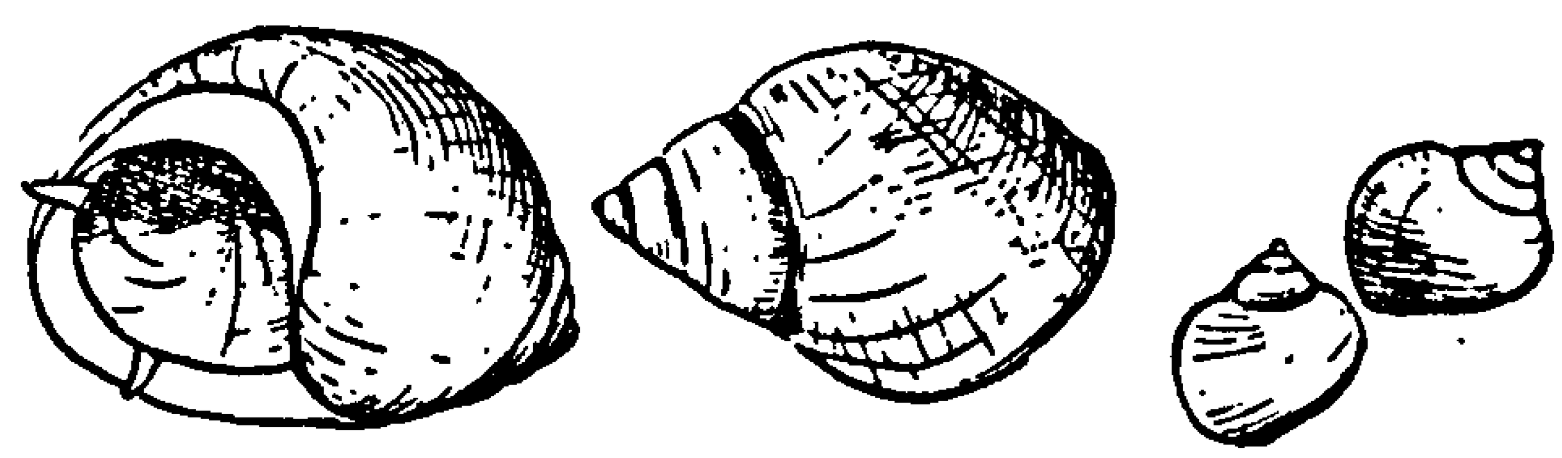




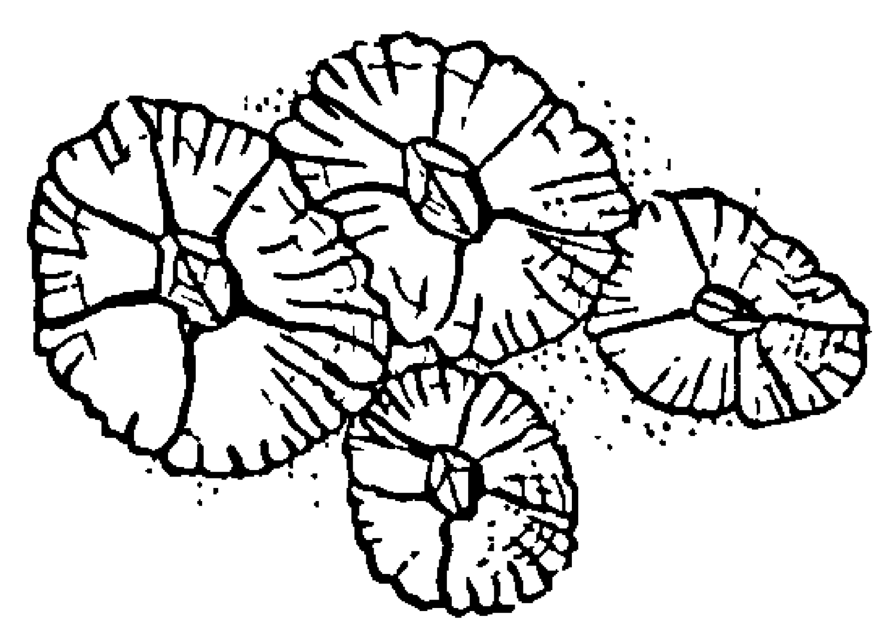
CHITON

STARFISH

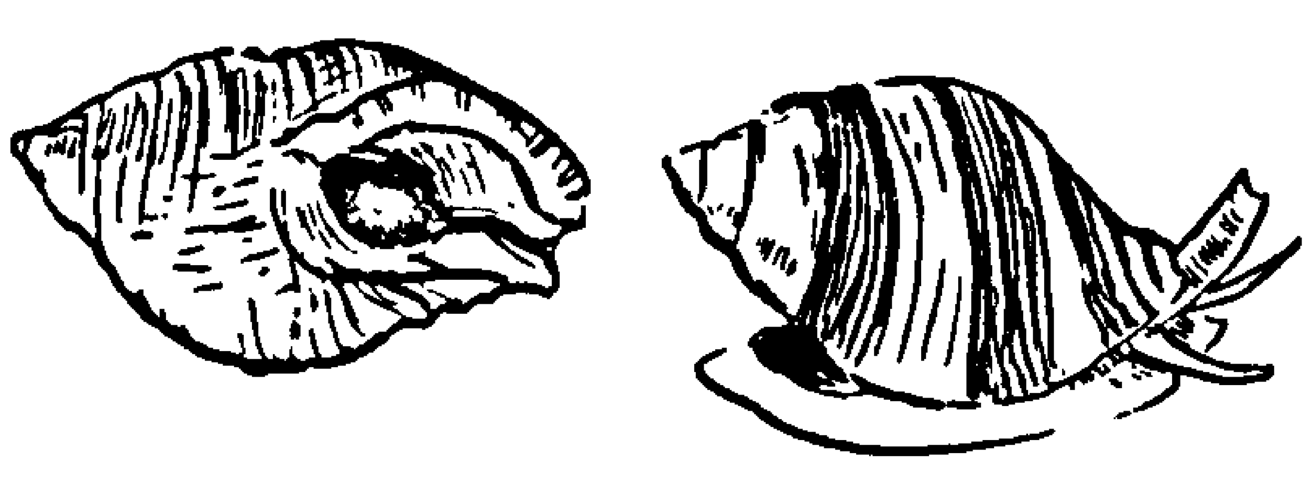




PERIWINKLES



BARNACLES



DOG WHELKS

For each species that you find, record the following.

a. On what did you find it? Rock? Seaweed?

b. Where abouts on the shore did you find it?

c. Does it appear to have any special adaptations to enable it to survive on the rocky shore?

d. If you can find examples covered with water, do they appear different to those exposed?

e. Are they near any other species?

The Mussel

One common, and often highly prized, inhabitant of the seashore is the Mussel. If you are able to find a specimen collect it and place it in sea water for transport back to the laboratory.

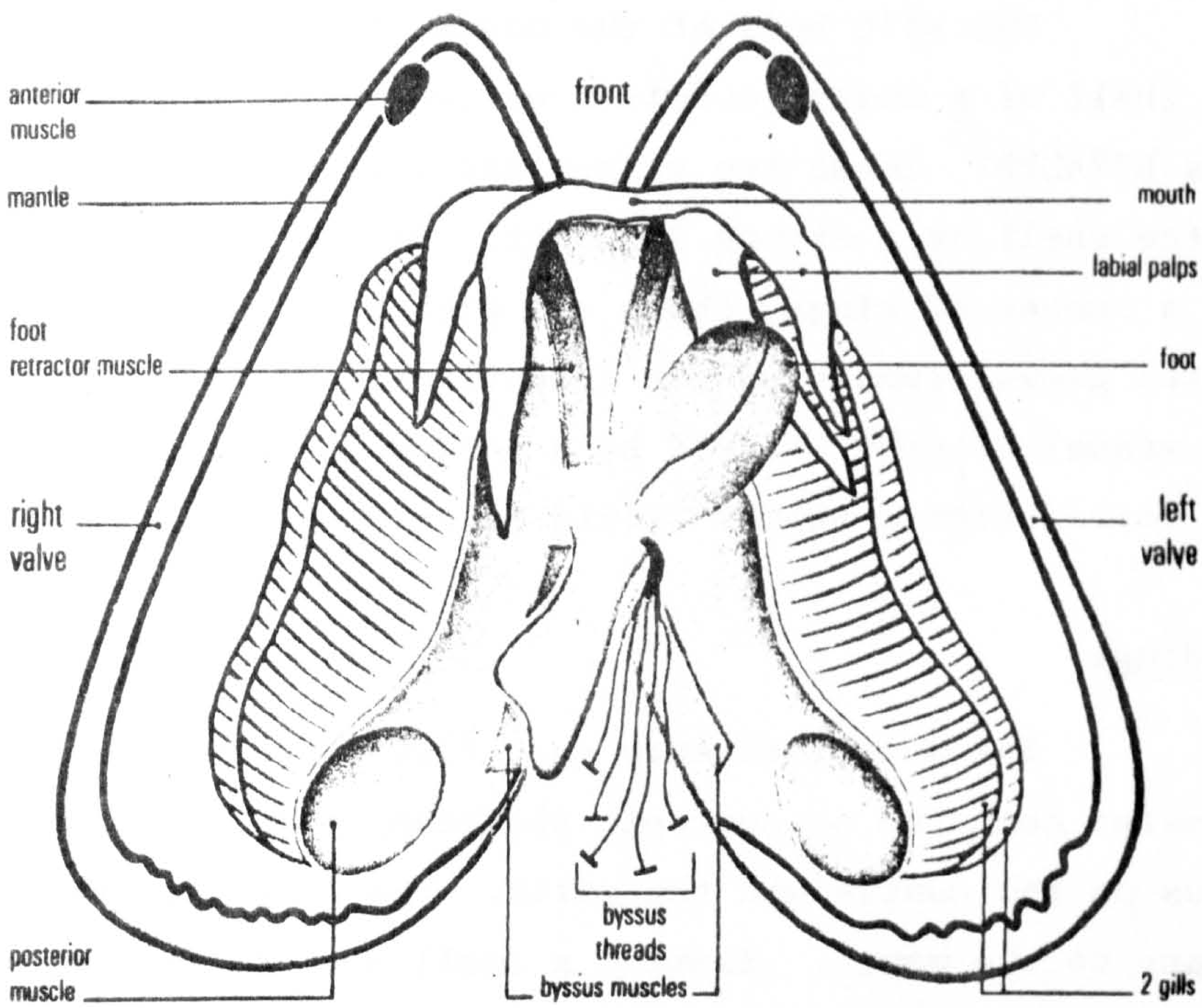
Examine the mussel carefully, and answer the following.

a. How many parts are there to the shell? These parts are called VALVES.

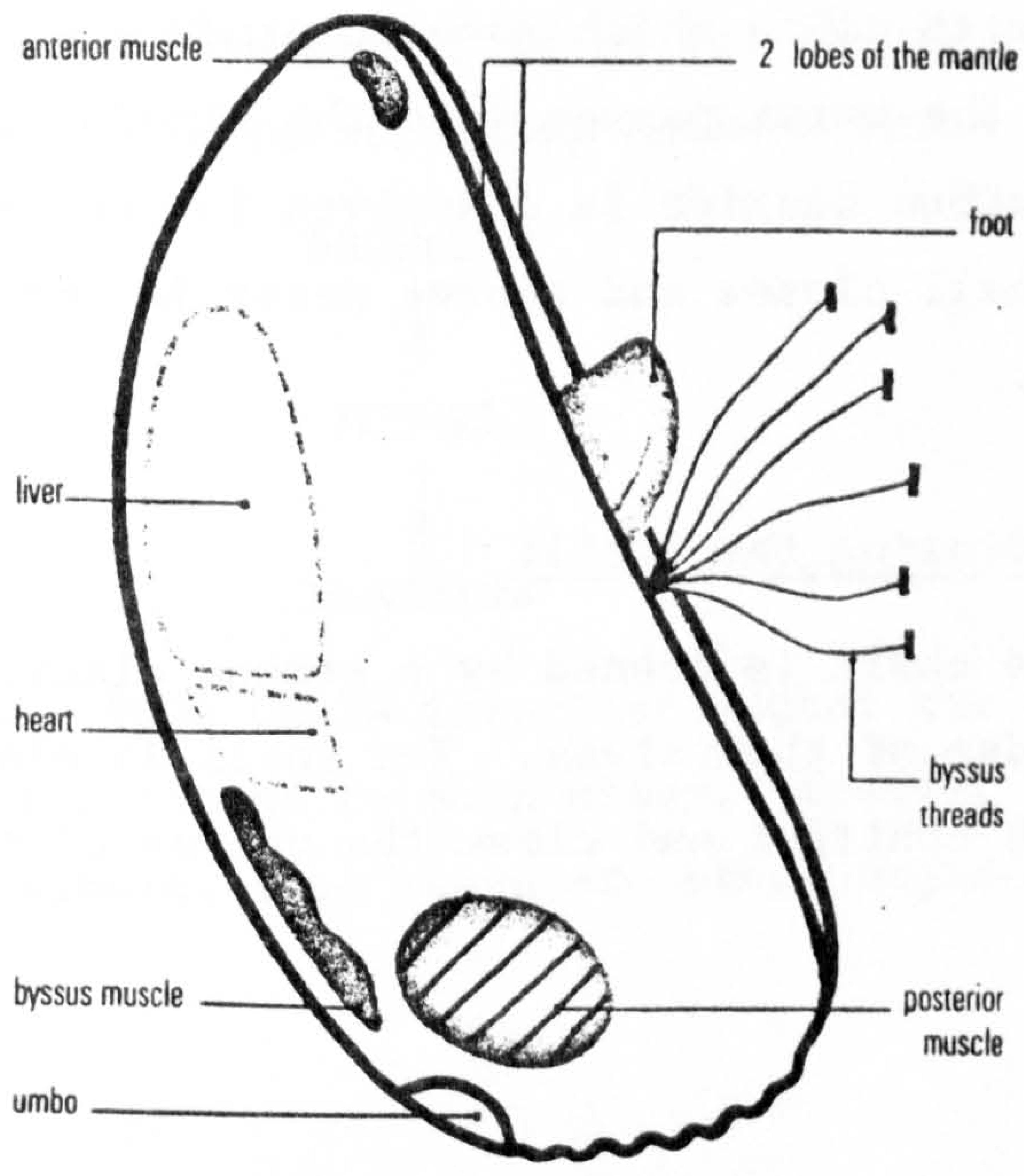
b. What can you see on the surface of the VALVES?

c. If the BYSSUS thread is still attached, examine it carefully. What can be found at the end of the thread.

d. Using a sharp knife or scalpel cut through the muscle which holds the valves together as shown. Open out the mussel and compare it to the diagram below.



e. Carefully sliding a knife between the mussel and the shell remove the mussel body from the shell. Compare it to the diagram below.



Read through the following notes on the mussel, referring to the organism as you do so. Identify each structure as it is mentioned.

Structure:

The soft body of the mussel is protected by a hard shell. The shell of a mussel consists of two parts, and the mussel is known as a BIVALVE. These two valves are held together on the dorsal side of the shell by a strong ligament. On the surface of the shell there are a number of rings, these are growth rings. The rate at which the mussel grows depends on the temperature and the amount of food available. The mussel attaches itself by a series of threads. The Byssus threads are formed from a sticky liquid secreted by the Byssus gland.

Feeding:

The mussel depends on a flow of seawater for its food. The seawater contains microscopic plankton which become trapped in the mucus on the mantle and the gills. The food is moved by cilia on these organs to the mouth. Examine a small part of the gills under a microscope, you should be able to observe the cilia. There is also a stomach, intestine and anus.

Respiration:

On each side of the mussel, there are two gills. These gills are covered with cilia which move to produce a current of water. Oxygen dissolved in the water passes into the blood circulation through the gills, and carbon dioxide is dissolved in the sea water. When the tide is out the shell closes and stores water in the mussel, which keeps the mussel alive.

Opening and Closing the Shell:

The shell is opened by a strong elastic ligament connected to the dorsal edge of the valves. The shell is closed by two adductor muscles which contract and close the valves of the shell.

Having carried out the observations and read through the notes on the mussel. Describe below the adaptations that enables the mussel to live in the seashore ecosystem.

<u>Assignment</u>:

<u>Food Chains and Food Webs</u>

In the exercise on the mussel you saw that the mussel filtered small organisms called plankton from seawater. On your observations on the seashore you may have found dog whelks near to mussels. Mussels are the main food of dog whelks. So we can see that there exists a simple relationship between these organisms.

DOGWHELK
|
MUSSEL
|
PLANKTON

This simple FOOD CHAIN illustrates that the organism on the seashore are interrelated to each other. However the relationships are not really all simple, thus there are other organisms that live on mussels and plankton while dog whelks have other foods, and so a better description of one type of interrelationship on the seashore is the FOOD WEB.

Below is a list of some of the more common inhabitants of the seashore and their main food sources. Use this information to construct a food web.

ACORN BARNACLE	-	PLANKTON
PERIWINKLES	-	SEAWEEDS, ALGAE ON ROCKS
DOG WHELKS	-	MUSSELS, BARNACLES
MUSSELS	-	PLANKTON
CHITONS	-	ALGAE ON ROCKS
STARFISH	-	MUSSELS

Project:

1. Seaweed although not commonly used for food in Newfoundland, in fact is a valuable food source in many parts of the world. Find out what you can about the uses of seaweed.

2. Many of the organisms on the seashore have interesting life histories. Find out as much as you can about any one of them other than the mussel. Note any adaptations that enable it to live on the seashore.

3. Use some seaweed mounts to make greeting cards or classroom decoration. A little care and imagination can result in very attractive compositions.

VI. MAN AND THE SEA

At the present time man has reached a critical period in his history. Many of his traditional resources are being rapidly depleted as a result of increasing demands for food, space and energy. More and more man is beginning to look towards the oceans and the ocean floors in order to find new resources. In the future we can forsee that we will obtain from the sea more than just our traditional supplies of food. In this final section we will consider some aspects of this new attention to the resources of the sea, and how we might be affected in the future.

The Sea - A Place to Live?

Many people have predicted that man might one day be forced to live in underwater cities. Although this might appear to be an idea from a science-fiction book, in fact already scientists are experimenting with underwater habitats which will enable man to exist for long periods under the sea. In Newfoundland an experimental habitat, LORA I (Low - temperature Ocean Research Activity) was established in 1971 to provide an underwater laboratory. The following account of L.O.R.A. I is provided by kind permission of Dr. R. T. Dempster, Dean of Engineering at Memorial University.

In developing the design criteria it was decided that the habitat should be located in 35 to 40 feet of water and thus be non-saturated, so that people of average diving capability could use it. We hoped to popularize and encourage underwater research because of our belief that to solve problems in the ocean requires that people experience being in it. In this way they are better able to understand the special constraints of this environment. Obviously we had no desire to design a facility that could be used only by professional divers.

The structure had to be simple to construct and easy to install, requiring the minimum of site preparation. These criteria logically lead to our chosing commercially available, off-the-shelf equipment and instrumentation. In addition, the habitat had to be situated close to the University, to reduce travelling time, and on a location with a flat, bed-rock bottom for the anchoring system. Such a site was eventually found 12 miles from the University at St. Phillips, Conception Bay.

The main shell of LORA is made from an old cylindrical fish digestor tank, 8 feet in diameter and 16 feet long with a 5/8 inch wall thickness. This tank was modified to permit installation of two 30 inch diameter acrylic plastic domes, one in the end and another on the topside of the tank when lying horizontally. The end opposite the one with the dome has a flat disk of plastic fitted as a third viewing port. On the bottom side of the shell about midway along its length is a 3 feet diameter entrance hatch. The shell is held horizontally on a rectangular base frame of one foot H-beam, 9 X 16 feet, by three equally spaced hold down frames made of 6 inch U-channel. Four legs, of one foot H-beam and 4 feet long, support the shell and base frame. The total weight of the structure is 11 tons and the estimated cost of the complete structure is $5,000.

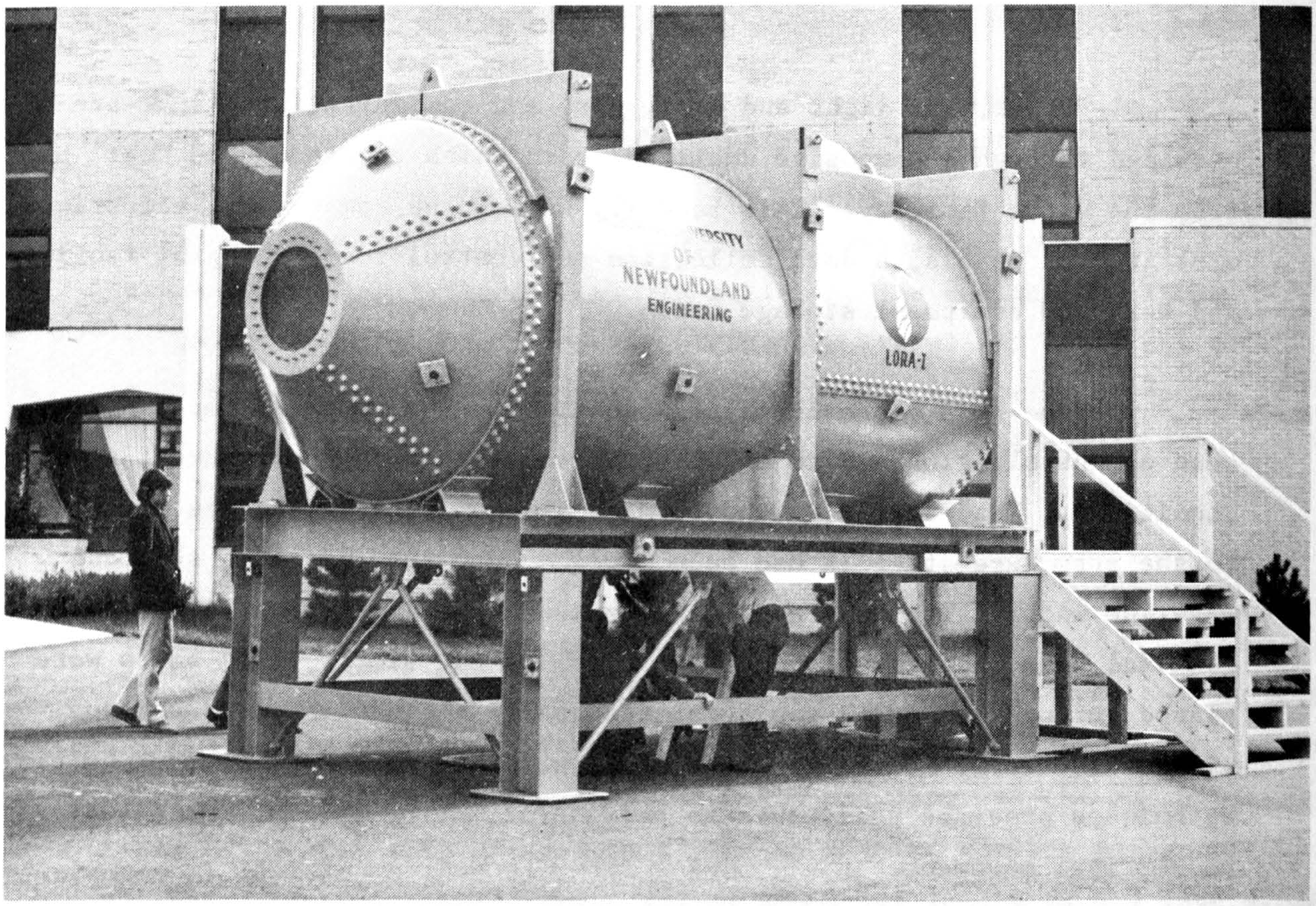
The interior of LORA is laid out to provide comfortable quarters for two men. The living area includes sanitation and cooking facilities, food storage area, sink and fresh water supply, communications equipment and berths. The work area, or wet-room, takes up approximately one half of the interior and contains tank storage racks, hookah supply system, suit storage area and the entry hatch. The interior is maintained at 70 - 80°F and 45 - 65 percent, relative humidity, using electric heat. A 2 inch thick foam urethane material coats the hull interior to provide thermal insulation. The ventilation system uses compressed air, with flow rates and patterns adjusted to maintain CO_2 levels within Canadian breathing gas standards.

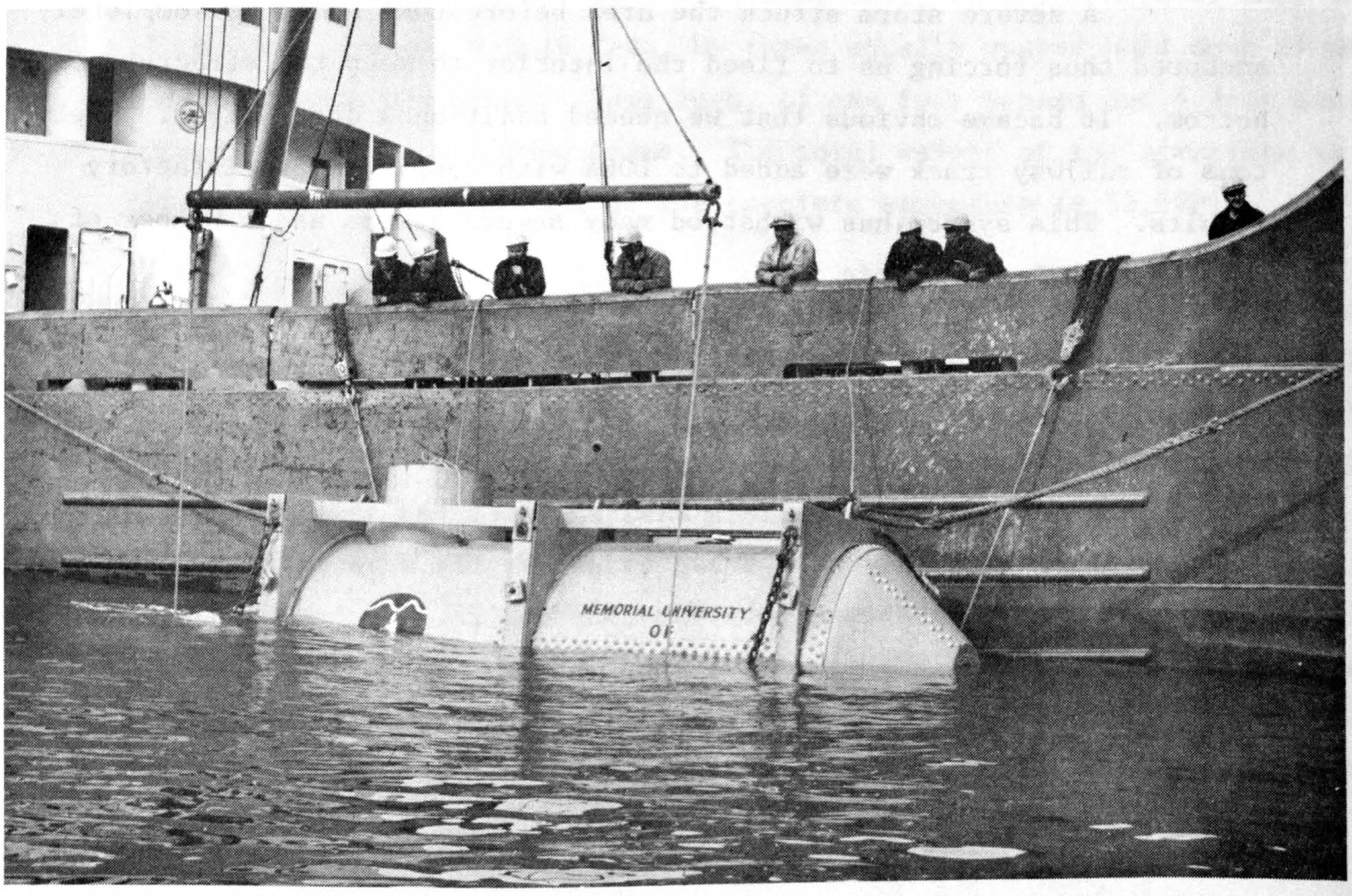
Power, for light and heat, air, and communications links are provided through a composite umbilical cord which runs some 500 feet from the shore facility. This facility houses the compressor, electrical distribution panels, a data collection and control room, changing facilities, and work and equipment storage areas.

The LORA anchoring system consists of two types of mooring for ease of installation and to ensure resistance to even the severest storm conditions. Dead weight in the form of six concrete blocks was attached to the structure after it had been lowered over the side of a ship and into the water. The habitat floated without these concrete blocks. When LORA had been weighted down to the bottom by the blocks, rock bolts were placed through the footing plates attached to the habitat legs and guy wires, also rocky bolted to the bottom, were attached. These rock bolting techniques provided resistance to horizontal motion and to some extent to vertical movement.

A severe storm struck the area before LORA could be completely anchored thus forcing us to flood the interior to keep the structure on the bottom. It became obvious that we needed additional dead weight. Twelve tons of railway track were added to LORA with completely satisfactory results. This system has withstood many severe storms and a number of impacts with heavy arctic ice.

Summarize below what you consider the main problems to be in installing an underwater habitat, and how these might be solved.





The above two photographs are of L.O.R.A. I.

(Top) At Memorial University. (Bottom) Being lowered into position.

The Seal-Hunt

One of the most hotly debated issues of recent times has been the seal hunt. The arguments for and against it have been put many times. In this type of issue it is important to identify all the arguments both for and against, so that whatever your point of view you are informed. The arguments on the seal hunt range around such issues as traditional life-styles, alleged cruelty, seal herd depletion and fish stocks. With the help of the teacher analyze below as many points as you can both for and against the seal hunt. Maybe your class can have a debate on the issue.

Oil from the Sea

In recent years a considerable programme of exploration for oil has taken place off the coast of the province. If oil is discovered we expect that it will benefit the Province's economy enormously. However, there may be side effects that you have not considered before. In Britain the oil found under the North Sea promises to be a big benefit, however, it has also brought big changes other than economic ones. Aberdeen which was once a quiet coastal town is now a bustling centre, and the life-style of its people has altered drastically. What effects do you think the discovery of oil might have in the province? What might planners try to do to anticipate these effects?